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Construction Plant at Hiwassee Dam—Cableway Towers at Opposite Sides of Valley; Mixer Plant at Left; Water Tank at Right; Whirler Crane in Power House Area. See First Article in This Issue

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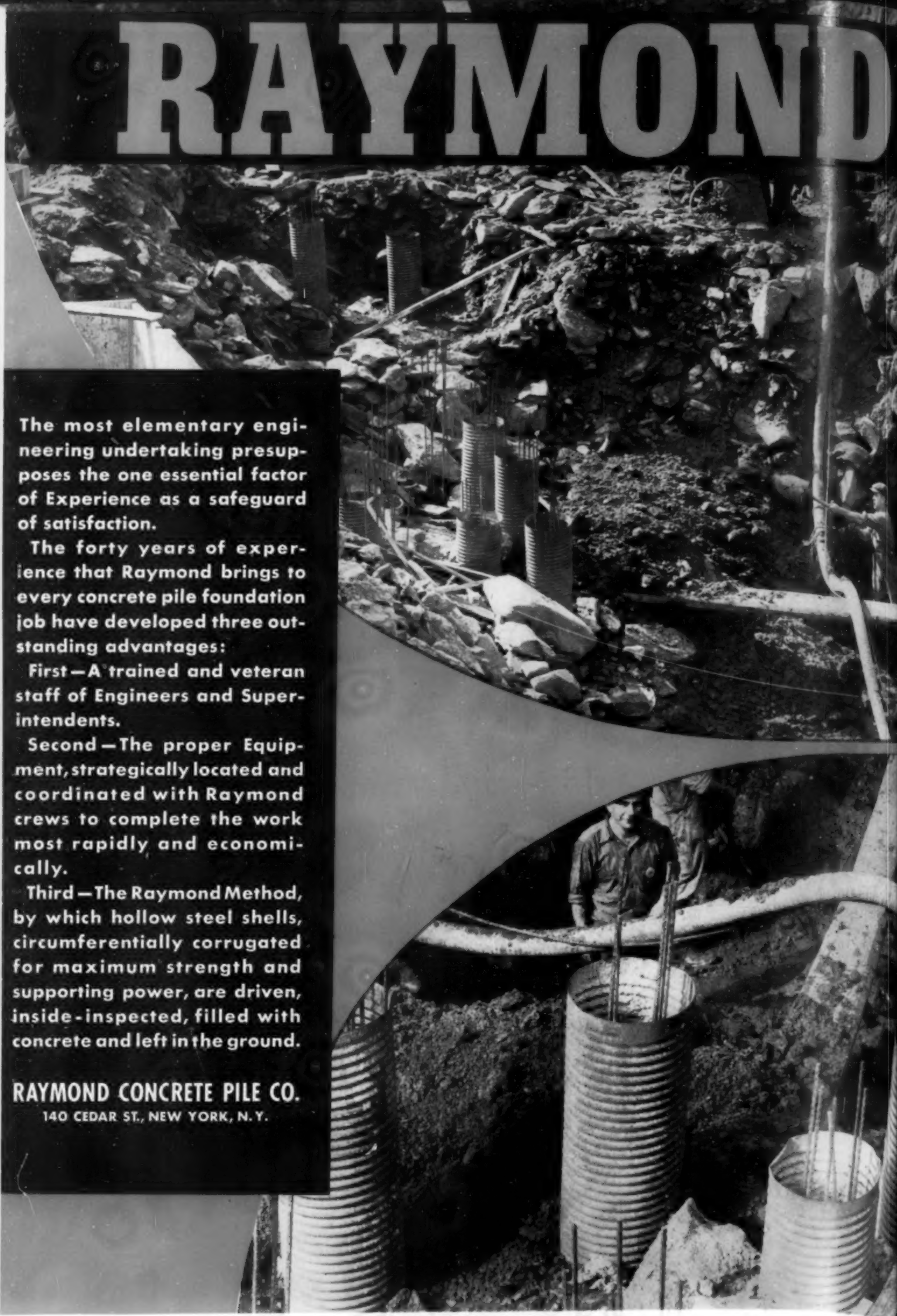
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Among Our Writers

Donald H. Sawyer's early record includes four years as chief engineer of the Illinois Traction system and eight as a member of the firm of Sawyer Brothers in Washington State. He served in the Quartermaster Corps during the War, was secretary of Associated General Contractors of America from 1923 to 1930, and was director of the Federal Employment Stabilization Board from 1931 to 1935.

R. T. Colburn became construction plant engineer for TVA in 1937, after three years as assistant construction plant engineer. He went to TVA from Stone and Webster, where he had spent seven years on design and hydraulic engineering in connection with steam and hydro power plants.

Charles E. Wuerpel began specializing in concrete in 1929, when put in charge of concrete construction on Bonnet Carré Spillway. His entire concrete experience has been with the U. S. Engineer Department, and has included important assignments on the New Harvey Lock at New Orleans, on Lock No. 26 at Alton, Ill., and at Passamaquoddy.

Fred C. Scobey has specialized for 25 years in the carrying capacity of water conduits of all kinds. He is an ardent advocate of "observational hydraulics," and all his analyses and recommendations have been based on careful field tests of full-sized conduits in "commercial" operation. He is chairman of the Society's Hydraulics Division.

J. L. Savage's engineering career began in 1903 with the U. S. Reclamation Service. Between 1908 and 1916 he was in private practice with A. J. Wiley, on irrigation and hydroelectric projects. In 1916 he was put in charge of all civil engineering design for the Bureau of Reclamation, and in 1924 was promoted to his present position.

Ned H. Sayford for more than 25 years has been a member of a consulting firm practicing in flood control, stream regulation, irrigation, and hydraulic work. He has directed the Engineering Service Division and the Maps and Surveys Division of TVA since their inception.

H. George Altvater (U. of Colorado, 1922) has had wide experience in transportation development—bridges with Harrington, Howard and Ash, and Modjeski, Masters and Chase; terminal facilities with the Pennsylvania and the C. & O.; and subways with the Board of Transportation, New York City. During the War he was technical assistant to Milo S. Ketchum.

D. J. Bleifuss (Minnesota, 1920) has been engaged in design and construction of hydro plants since 1923. Since 1932 he has spent considerable time in developing aluminum as a structural material.

B. J. Fletcher (M. I. T., 1924) was engaged in water power surveys and hydroelectric construction in the South for five years. Since 1930 he has been active in design, experimental, and fabrication work in structural aluminum.

Otis Ellis Hovey tells his own story, at least in part, in his article in this issue. For 45 years a member of the Society, Dr. Hovey has served as its Treasurer since 1921, and was elected to honorary membership in 1937. He is the director of Engineering Foundation, and a consulting engineer.

Richard A. Hertzler served for four years as resident engineer at the Pennsylvania Military Reservation. He went with the Appalachian Forest Experiment Station in 1934, and his present duties there include data analysis and supervision of data compilation.

Edwin B. Eckel's work has been largely in mining geology and—in the past four years—in engineering geologic problems, particularly dam foundations. At present he is engaged on examination of dam sites on the Green and Yampa Rivers (Utah) for the Bureau of Reclamation.

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Something to Think About

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Frontiers of Engineering

Abstract of Presidential Address Delivered at the 1939 Convention in San Francisco

By Donald H. Sawyer

President, American Society of Civil Engineers

Chief, Section of Space Control, U. S. Treasury Department, Procurement Division, Washington, D.C.

PROGRESS, although viewed in some circles as a glorious symbol of more speed and bigger machines and in others as a covering for inhuman materialism, is in reality a conception embodying the most profound and the most potent ideas at work in the modern age. It is, at the same time, an interpretation of the long history of mankind and a philosophy of action in this world of bewildering choices. It gives meaning to the rise of civilization out of the crudities of primitive barbarism and offers a guide to the immense future.

Progress or Stagnation?~In essence, the idea of progress belongs to our own times, for it was not known to the ancients. It has become more than a theory; it has achievements to its credit on every hand—disease and pain alleviated, the span of life lengthened, famine made obsolete, and improvements developed in every field of endeavor. Of course, progress is born of faith—faith that the world, as Emerson stated, "is all gates, all opportunities, strings of tension to be struck." This faith confronts obstacles with assurance; where the pessimists face the worst, it proposes a search for the best. From suffering, ignorance, and fear, which drive the timid to the nirvana of doubt and oblivion, this faith calls to action, to research, to planning, to conquest, to a naked avowal that the earth is to be made submissive to them that dwell thereon.

In very recent years, however, we have listened to a new slogan to the effect that there are no more frontiers in America. It is quite true that migration from the Eastern shore to the Pacific Coast has been completed, that the intervening areas have been adapted to agriculture and industry in large part. But this does not imply that all the open spaces are productively at work, and especially it does not mean that Americans, most favored people in the world, are satisfied with their present surroundings and facilities.

The discovery of gold in California spurred inventors and engineers to develop the railway—and today we boast the greatest network of railroads of any country in the world. Where once it took months for a slow-moving animal-drawn caravan to cross the country, railroad trains now require only two and one-half days. Airplanes have reduced their schedules to fifteen hours, while passenger automobiles can make the journey comfortably in a week.

Amazing Advances.~Tremendous strides have been made since the gold rush to California. Instead of months once required to round the Horn, today fast steamships complete the journey from coast to coast, through the Panama Canal, in two weeks. The engineer has justly taken credit for all these advancements in science.

If it be true that the territorial frontiers have been surmounted, can it be said that the frontiers of technical advancement have likewise been reached? If the answer to this question is affirmative or is couched in doubtful language, the only conclusion is that America must accommodate itself to tremendous changes. But the answer is "no"; and although the fundamentals for a higher civilization have been provided there will be no pause in the thinking and accomplishments of the technicians of this nation for years to come.

The engineer has not yet reached his frontier nor has he even come in sight of it. Probity of mind, clarity of thinking, trust in his own self-assurance, opportunity for public service—all these constitute mental and physical resources, which show no indication of exhaustion but rather have provided him with tools that permit him to perform even greater deeds for mankind.

Many Efforts Combined.~It is well, in contemplating the equipment of the engineer, to recognize the mental and physical forces which join hands with him in developing his enterprises. Roughly his colleagues are men and materials. Construction involves the manipulation of these elements, and millions of people have given of their best to this great productive development. Through

a long sequence of complex operations, they trace the ore and the timber from its natural habitat to its final placement in a completed structure.

This business adds to the permanent wealth of the country and is second only to agriculture in its vast volume. It constitutes the greatest single force that has made the United States the leader of the world in providing necessities, conveniences, and luxuries for its people.

Setback Entails Hardships.—This great army of men has been steadily advancing for a hundred years. Its progress continued until the early 1930's, when something occurred that interrupted its forward movement. Since then this great part of American business and life has staggered in an effort to recover its lost ground. Many tonics, many medicines and panaceas, and great profusions of words have been administered in valiant attempts toward resuscitation. In spite of all these efforts industry is today far below its legitimate level.

While great credit must be given to the engineer for the benefits he has conferred on modern life, it must be realized that in gaining his high position he has carried along with him a section of humanity for which he must stand sponsor if he remains true to his faith. No one can accurately estimate how many men look to the construction industry for their livelihood, but the best available figures range from 5,000,000 to 8,000,000 human beings.

A Challenge to Engineers.—And so the technical man—qualified as he is and distinguished in trustworthiness, thinking, and zeal for public service—must pick up this load if the United States is to have substantial recovery. So long had he been ingrained with confidence in a market for his creations that he was not prepared for the shock of the depression. He floundered, became discouraged, accepted the fallacy that America had no more frontiers, and somewhat succumbed to an undefined bewilderment. He must shake off his apathy and his recourse to temporary alternatives. He must revive his clear thinking, reassert his courage and inventive genius, and again take up his full share of the burden.

To do so involves no great departure from the engineer's former habits of mind. If he will not reassert himself, he and his industry must continue to suffer; but if he will go forward he will do for America greater things than have been accomplished in the past and will play his full part in bringing the nation out of its difficulties.

But, why "pick on" the engineer and charge him with leadership in such a program? The answer is that he has always been in the key position of the construction industry. His have been the ideas, his the means by which these plans can be brought to reality. He has been the captain of the construction team, and it is his function to call the signals and to direct the plays along lines that give assurance of success.

Creative Improvements.—There seem to be no short cuts to a substantial return of the former volume of construction. No miracle man is in sight who can lead America out of the present wilderness. The road back must include hard work, good judgment, and the revitalization of creative genius.

Eternal change has been the life blood of the construction industry, whose slogan has been, "Don't do today what you did yesterday; do something better." Indicative of the striking changes of the last half century are many available illustrations, all of which emphasize the trite saying, "Off with the old, on with the new." Few facilities and improvements in America disappear because their usefulness has passed; most of them are displaced because something better has been introduced that promises higher service.

One bright spot where American creative genius has maintained the pace of former years is the chemical industry. This sector of American business has been alive in devising products that a waiting public might acquire. Brand new creations have appeared in recent years that were never thought of before, and eager buyers have absorbed them.

In the engineering field, air-conditioning of our buildings was launched as an adventure a few years ago and today its application is found in a wide variety of structures and railway accommodations. The latter-day adaptation of internal combustion motors to railway transportation with lighter and more modernized equipment forecasts a trend that, with the greater improvements bound to follow, is entirely revolutionizing travel by rail. These examples of creative contributions to American technical life may be largely multiplied.

A Program.—Still greater sums must be set aside for research, and capable staffs must be formed to develop new ideas which show promise for commercial use. This money should be allocated to laboratories and research institutions, as well as to manufacturers and technicians, wherever the assurance seems justified that its distribution will lead to betterments. The federal government, if properly advised of the purposes to which an appropriation would be devoted and of the reliable auspices under which the spending would be conducted, might give consideration to legislation that would motivate a program. The unified support of the industry should be behind a program of this nature.

The creation of new facilities is the target at which to shoot. Americans have an appetite for the best that life affords. As a companion movement, therefore, the industry must devise all proper means to acquaint the public with what it has to offer. When this great machine is in working order, with money, man-power, and materials, and with a public eager for the best, the sale of its wares whenever properly presented can be expected.

The American Society of Civil Engineers is so organized as to give at least initial momentum to such a procedure. Its twelve Technical Divisions speak for specialized engineering. These groups can well examine and explore this problem and they can become the motivating forces in this program to restore construction. Out of such efforts might come a highly qualified committee to give direction to the formulation of future plans.

If this business will shake off its lethargy, reestablish its belief in itself, and work industriously, we can face the future with a revived confidence and with convictions; we can pick up our load and quickly start American business on the upgrade.

American ingenuity has not finished its course.
The fertility of the technical mind is not exhausted.
The frontiers of engineering have not been reached!

DONALD H. SAWYER
President

GEORGE T. SEABURY
Secretary

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NUMBER 8

Construction Plant Planning for Large Dams

Sixth of a Series on Modern Construction Tools and Practice

By R. T. COLBURN

MEMBER AMERICAN SOCIETY OF CIVIL ENGINEERS
CONSTRUCTION PLANT ENGINEER, TENNESSEE VALLEY AUTHORITY, KNOXVILLE, TENN.

THE general trend in heavy dam construction today, says Mr. Colburn, is toward closer co-operation between engineer, designer, and builder; more thorough administration and control of construction equipment; more careful planning of plant; and more studied attention to processes and methods. All these things, he points out, make for finished structures of higher quality at lower cost.

Examples of construction plant planning in this article are drawn from the wide experience of the TVA. Administration of equipment is the first major topic; the remainder of the discussion is concerned with individual plant items of particular importance. Mr. Colburn's contribution is part of a paper presented before the Construction Division at the Society's 1939 Spring Meeting.

WHEN the first bucket of concrete was poured in July 1934 on the Tennessee Valley Authority's 1,000,000-cu yd Norris Dam, it was said that the dam was one-third completed. This seemingly exaggerated statement has considerable basis in fact; and it serves well to show the relative extent of the preliminary work necessary on large construction projects. The importance of a construction plant well planned and organized is being more universally recognized by the construction industry today than ever before.

The building of possibly ten dams, in regular sequence, by the TVA has provided a unique opportunity for systematic and economical construction plant planning. Soon after the Authority began operation, in 1933, a Construction Plant Division was created within the Construction Department to centralize the work of studying, estimating, and designing the main construction plant for each project; administering the approximately $5,000,000 worth of construction equipment required; analyzing and keeping close watch on construction unit costs; assembling up-to-date construction cost data; and checking construction estimates. This Division was organized to work in cooperation with the officials on each project, with its general studies and recommendations subject to final approval by the individual project engineers, who are responsible for the work on their respective projects. The close cooperation between the central construction plant office and the field office is a major factor in the success of this policy.

Efficient administration of construction equipment is vital to economical management of the construction of large projects. Methods used in administration of dam construction equipment by the TVA have been developed over a considerable period of time, the objective being to provide the most economical use of equipment throughout the Authority with the least "red tape." Equipment requisitioned by any project must be justified either by the need for it on that project or by a combination of needs on several projects. Each project is prepared to absorb the entire cost of the equipment it requisitions, but salvage or transfer credits are later given when the equipment is disposed of or placed on another project. All requisitions are checked by the central construction plant office against availability lists, and where possible are filled by the transfer of the required equipment from other projects. If the equipment is not available, specifications are written, bids taken, and recommendation for purchase made.

One of the basic principles early established in connection with equipment purchases was that the lowest construction costs usually result from the use of the best and not necessarily the cheapest equipment on the market. Specifications are written after thorough study of the merits of all the different types of equipment on the market. The result has been the purchase of good equipment under specifications which are fair to all bidders and based on actual merit and experience. In some cases actual tests have been conducted to establish definitely the merits of several makes of the same type

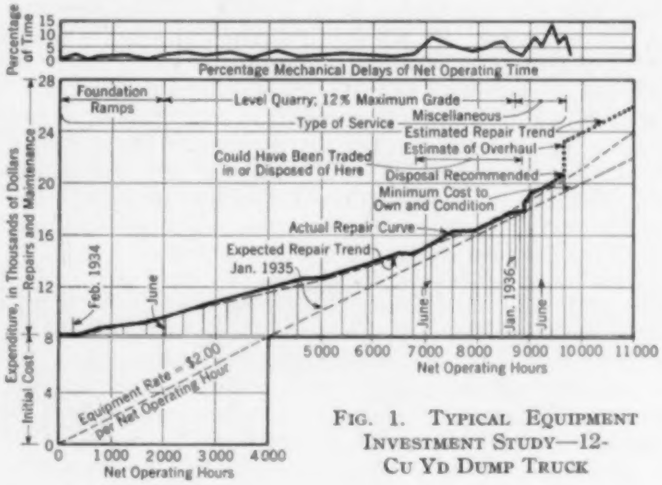

FIG. 1. TYPICAL EQUIPMENT INVESTMENT STUDY—12-CU YD DUMP TRUCK

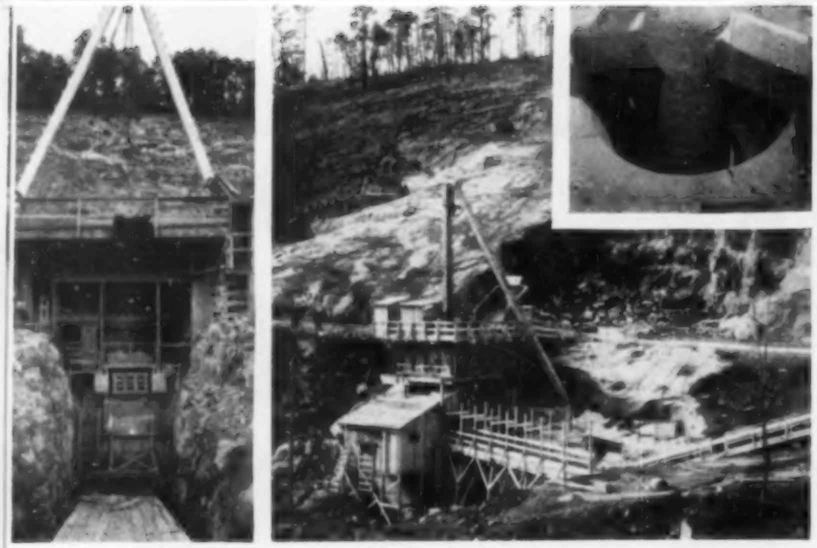

FIG. 2. THE SAME PRIMARY CRUSHER WAS USED ON THREE PROJECTS
Left, Norris; Right, Hiwassee (the Present Location); Upper Right, a Detail of the Installation at Chickamauga

of equipment for our particular use. Records of performance and repairs to TVA equipment are being made continuously, and these records are analyzed and used to justify the purchase or rejection of new equipment.

A register is kept of all construction equipment in the central construction plant office, showing the location, first cost, size, manufacturer, date of purchase, and previous transfers. Each item in the register is further supported by a record giving complete description and engineering data, repair costs, and so forth. Availability lists and condition reports of equipment are kept up to date, and summaries are issued periodically showing the locations, classes, and quantities of all construction equipment.

From time to time the central office makes a schedule study of certain types of equipment in order to forecast the need of the projects several months in advance, arrange if possible construction schedules to stagger equipment use, keep all equipment working, and reduce new purchases to a minimum. As an example, the scheduling of cofferdam construction and dismantling on three projects—Pickwick Landing, Guntersville, and Chickamauga—was so arranged that four skid derricks, three whirley barges, eleven cargo barges, and a minimum of other supplementary equipment, could handle all the cofferdam construction at all three locations, with a minimum detriment to the individual project schedules and maximum over-all benefit to the TVA.

DETERMINING WHEN EQUIPMENT SHOULD BE DISPOSED OF

On all major equipment the central office maintains up-to-date charts like that of Fig. 1, showing the first cost, expected and actual repair trend equipment use-rate, hours of use, and type of service. These curves—originated by P. H. Kline, Construction Plant Operations Engineer of the TVA—are watched by the job officials, and disposal of any piece of equipment by trade-in or sale is recommended when the cost of using it becomes higher than the normal use-rate. The example shown indicates a 12-yd truck, the first cost of which is \$8,236. The sloping line, drawn from zero tangent to the repair curve, represents the use-rate, which for this unit is \$2 per net operating hour. This particular case shows that after 9,700 hours of operation a heavy overhaul is required, and the future cost of ownership is greater than the use-rate up to this point. The truck should be sold at this point or traded in for a replacement. The curve also indicates that the truck could have been traded in at 7,000 hours at no greatly increased ownership expense and probably with reduced mechanical delays. It is the responsibility of each project to keep its equipment in good repair and transfer it in good operating condition.

All transfers of equipment are cleared through the central office, the total number per year averaging about 1,000. The first-cost value of all equipment on hand June 30, 1939, was approximately \$4,800,000. The transfer value of all equipment transferred to the same date was approximately \$2,650,000.

The central construction plant design office has successfully adapted many major construction plant structures and large units of TVA-owned equipment to new conditions on succeeding projects. For example, Fig. 2 shows a 42-in. gyratory crusher as it was used on three projects. The original setting is at Norris Dam, where this crusher handled two million tons of dolomite rock. The second setting is at Chickamauga Dam, where the same crusher with certain alterations handled a million tons of limestone rock. The third setting is shown at Hiwassee Dam, where the crusher is now located and is expected to crush two million tons of graywacke rock. This transfer was closely timed; the crushing plant was shut down at Chickamauga Dam on December 13, 1937, and the crusher was placed on its new foundations in time to go into service at Hiwassee Dam on January 14, 1938.

Again, one of the two 18-ton cableways first used at Norris Dam is now in operation at Hiwassee Dam (Fig. 3). The original span of 1,925 ft has been reduced to 1,450 ft, the position of the head and tail towers has been reversed, and new runways have been constructed. The saving realized between the cost of a new cableway at Hiwassee Dam and the transfer costs, including suitable depreciation allowances, was estimated at approximately \$65,000. The head tower and machinery on the other Norris cableway were sold for installation at Marshall Ford Dam in Texas.

In Fig. 4 is shown the mixer plant at Pickwick Landing Dam, and its second location at Hiwassee Dam. This plant was originally designed to use three 2-cu yd concrete mixers at Pickwick Dam. At Hiwassee these were replaced by the three 3-cu yd mixers from Norris Dam, and suitable alterations in the batching equipment were designed to handle this increased capacity.

As another example, 60 low-cost houses now occupied by the construction force at the Gilbertsville Dam were originally built and used at Pickwick Landing. They were transported 200 miles down river by barge, at a substantial saving over the cost of building new houses at the new site.

In most of these transfers it has been possible to make improvements in the original installation. Weaknesses and unsatisfactory conditions in the

FIG. 3. THIS CABLEWAY, AT HIWASSEE, PREVIOUSLY SERVED AT NORRIS. THE ORIGINAL CABLES ARE STILL IN USE

original setup have been largely eliminated in the second installation. Many other examples could be mentioned if space permitted.

The centering in each project of responsibility for the acquisition and maintenance of equipment, coupled with coordination through a central office, is an efficient compromise between completely decentralized individual project control and completely centralized methods. Over-all economies are thus obtained by taking advantage of centralized engineering design, control of equipment transfers, and scheduling between projects, without the loss of individual job responsibility or the maintenance of a large central administrative overhead.

The remainder of this article will be devoted to a brief discussion of individual plant items of particular importance—cableways, buckets, aggregate plants, mixing plants, and belt conveyors. [A separate paper on construction methods for cofferdams is scheduled for publication in a forthcoming issue.]

Use of cableways for concrete placing in canyon-type dam construction has increased greatly in the past ten years. The heavy-duty horizontal thrust-wheel

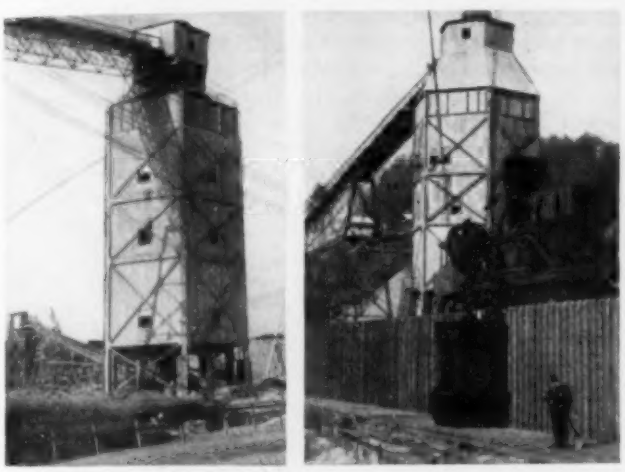

Fig. 4. The Mixer Plant Originally Used at Pickwick Landing (Left) Has Been Revamped and Transferred to Hiwassee (Right)

type of traveling cableway, first installed at Madden Dam, has been perfected and used on several projects recently. Hoover Dam was the second to use this type of cableway, and Norris Dam was the third installation, the latter cableway having an 18-ton capacity. Under the supervision of A. J. Ackerman, Assoc. M. Am. Soc. C.E., former Construction Plant Engineer for the TVA, who pioneered the Madden Dam installation, the Norris cableway design was perfected and many improvements were made. Properly maintained, the cableway towers and machinery can be used on several projects. The cable is subject to wear, but it should be noted that the same cable used on one of the cableways at Norris Dam is now being used at Hiwassee Dam, and although this second project is almost half completed, no evidence of failure has been noted so far. The exceptionally long life of the cable is attributed to regular systematic greasing and to rotating the cable one-eighth turn monthly in order to keep the wear evenly distributed. This inexpensive and careful maintenance by the job forces pays for itself many times over.

An important factor in successful cableway operation is a properly designed concrete bucket. Figure 5 shows a 6-yd bucket specially designed for the Norris cableway. Its principal features are: (1) the air dump, which provides a simple means of dumping the bucket almost instantaneously; (2) sufficiently delayed discharge to reduce the "bounce" of the bucket on the cableway to a minimum, provided for by baffles within the bucket itself; (3) 100-per cent opening of the bottom during dumping so that the bucket is completely cleaned; and (4) automatic reclosing of the gates after dumping. As soon as the load is released the weight of the handle on the dumping lever is sufficient to close the gates and set the safety latch. In this position it is not possible for the bottom gates to open unless the latch is released and unless the dumping levers are thrown past the center pin. In the closed position the weight of the load itself keeps the gates closed, and there is no chance for accidental dumping.

Fig. 5. Concrete Bucket (6-Yd Capacity) Used at Norris and Hiwassee

The Capacity Was Increased to 7 Yd at Hiwassee by Adding to Depth

CLOSE AGGREGATE CONTROL REDUCES CEMENT REQUIREMENTS

Production of aggregate is one of the main problems on any large concrete dam project. This topic has been covered in considerable detail by M. P. Anderson, Assoc. M. Am. Soc. C.E., in Civil Engineering for June 1939, "Large Plants for Aggregate Production," with particular attention to the manufacture of sand and aggregate from quarry rock. The aggregate plant at Hiwassee Dam is a good example of recent refinements in this process. (See "Production Methods at Hiwassee Dam Aggregate Plant," by F. Cadena, A.I.M.E. Technical Publication 1016, *Mining Technology*, January 1939.) This plant was laid out taking advantage of previous experience on both the Norris and the Chickamauga dams, and contains several special features which have resulted in very close control of aggregate production. As a consequence of this control, substantial savings have been effected in the amount of cement required for the concrete.

Briefly, the plant consists of a 42-in. gyratory primary crusher, discharging its products by belt conveyor to an

Fig. 6. Floating Mixer Plants at Wheeler Dam

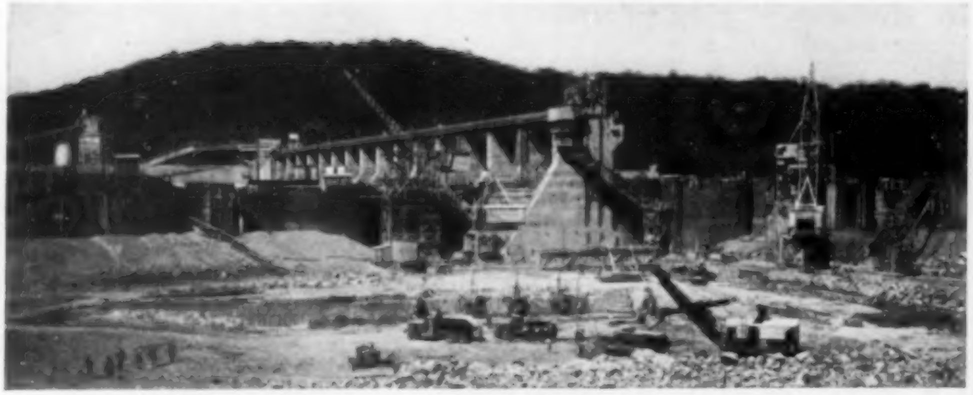

FIG. 7. GENERAL VIEW OF CONCRETE CONVEYORS AT GUNTERSVILLE

intermediate stockpile and the secondary crusher building, where a cone crusher and four hammermills are installed for production of sand and aggregate. From this building the product is carried by belt conveyor to the sizing screens on top of a screening structure, which stocks the material in four sizes of aggregate and releases the sand to dewatering equipment, from which it is placed in a stockpile over a tunnel.

Aggregate below the 6-in. size as produced by the primary crusher is brought to the top of the crusher building by belt conveyor. From that point the material is handled entirely by gravity flow to its final discharge on the reclaiming belt. The hammermills and secondary crusher are so arranged, with connecting chutes and a recirculating belt, that the excess material of any size can be reground to the smaller sizes. Thus the quantity of any one of the five sizes of aggregate and sand produced can be positively controlled.

At Hiwassee Dam there is a certain amount of free silica in the rock, necessitating a dust-control system. The use of exhaust fans with a duct system and hoods in the crusher building, and the wetting of the material to reduce dust concentrations in places where exhaust fans are not practical, have eliminated dust from these operations.

MIXERS THE HEART OF THE CONSTRUCTION PLANT; BELT CONVEYORS FOR TRANSPORTING CONCRETE

The heart of the construction plant on any large concrete dam project is the concrete mixer plant. The efficiency of this unit controls the output of concrete and determines the maximum rate of concrete placing. The other parts of the construction plant should be built to maintain the capacity determined upon for the mixer plant in order to assure a balanced installation. Most of the TVA mixer plants have been of the conventional type, particular emphasis being given to accurate batching of the aggregate, sand, cement, and water, and to proper proportions, consistency, and timing of the concrete mix. Fully automatic plants have not been used, although automatic control of the cement and water batching has been installed. This tends to simpler plant design and simpler maintenance, with only small additional operating cost.

A special set-up consisting of four floating mixer plants was used to pour the 625,000 yd of concrete required at Wheeler Dam (Fig. 6). This is an example of what can be done where cofferdams are low and close to the structure and river fluctuations are not great. Each mixer plant unit consisted of a 40 by 90-ft steel barge, which carried a 2-yd mixer with suitable batching equipment and small storage for aggregate and cement. A whirley crane, mounted on the rear of the barge, transferred aggregate from barges to the bins. These mixer plants could be floated to any position along the dam and power house. Since the completion of Wheeler Dam, one of them has been maintained for use on miscellaneous and detached concrete work on all the main river projects.

The TVA has achieved considerable success in the use of belt conveyors for transporting concrete in the different stages of construction from the mixer plant to a loading point near the center of construction operations. The set-up at Guntersville Dam is shown in Fig. 7. Here the use of a conveyor (placed sufficiently high to span the lock above navigation clearance) made it possible to establish the mixer plant in a permanent location on the flood plain on one side of the river, thus avoiding the necessity of temporary set-ups in each construction stage, with corresponding changes in the aggregate and cement feed to the mixer plant and the resulting expensive transfer costs. It has also kept the plant above the elevation of the top of the cofferdam and beyond the reach of ordinary floods.

The success of the conveyor system depends largely on so selecting the size and speed for the conveyor, and so designing the discharge on to the belt, the transfer points, and the hoppers at the end of the system, that segregation of the concrete is avoided. Considerable study and actual field trials have been made on different types of discharge gates and chutes. A conveyor system 1,200 ft long was successfully operated at both Chickamauga and Guntersville.

PLANT PLANNING PAYS DIVIDENDS

The examples given in this article have all been drawn from the work of the Tennessee Valley Authority. Nevertheless they are, I believe, typical of the general trend in heavy dam construction today—which is toward closer cooperation and understanding among the engineer the designer, and the builder; more thorough administration and control of construction equipment; more careful planning of plant and operations; and more studied attention to processes and methods.

The magnitude of the projects now under construction in this country is a constant challenge to the construction industry to keep abreast of the day-by-day developments in this field. The economic advantages sometimes obtainable by developing and designing special equipment for a particular job call for continuous engineering study and experiment. Not only does thorough engineering planning offer a plant capable of economical, sustained, trouble-free operation, and effective administration, but it also tends to provide a finished structure of higher quality at lower cost.

Acknowledgment is made to the following engineers of the Tennessee Valley Authority: A. J. Ackerman, former Construction Plant Engineer; L. A. Schmidt, Jr., Construction Plant Designing Engineer; H. P. Maxton, General Cost Engineer; and P. H. Kline, Construction Plant Operations Engineer. The first three are Associate Members, Am. Soc. C.E. The writer is indebted to Lee G. Warren, M. Am. Soc. C.E., Project Engineer of Chickamauga Dam, and F. T. Matthias, Assoc. M. Am. Soc. C.E., of the Construction Plant Division, for review and helpful criticism of this paper.

An Approach to the Design of Concrete Mixes

Choice of Water-Cement Ratio; Types and Properties of Cement

First of Two Articles on the Elements of Modern Concrete

By Charles E. Wuerpel

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In his opening paragraph, Mr. Wuerpel effectively strikes the keynote of both this article and the one to follow it in September: "Good concrete is that in which the blending of the component materials effectively meets the particular structural requirements of the member it forms. . . . The approach to effective design of a concrete mixture should be with the realization that the number of potential variables is infinite." The present article deals with two of the preliminary steps in mixture design—selection of water-cement ratio and of the type of cement to be used. Reversing the usual philosophy, Mr. Wuerpel recommends using the highest value of W/C commensurate with the demands for density and durability. As for cement—"Greater and more certain benefit may be derived from the intelligent choice of quantity than from unenlightened meddling with composition quality." However, much space is devoted to a discussion of specifications designed to secure the proper composition for special purposes. The second article will deal with choice of aggregates and actual mix design, with comments on vibration and curing.

These articles, it should be noted, are designed not for the "concrete expert" but for the engineer who has not been able to devote his time in recent years to the minutiae of the subject.

Hardened concrete is a coherent conglomeration of materials blended and molded in such manner as to meet specific structural requirements. Good concrete is that in which the blending of the component materials effectively meets the particular structural requirements of the member it forms. Since the demands made of concrete vary from those necessary for delicate architectural decorations, through protective building walls, swimming pools, highway slabs, bridges, aqueducts, and thin arch dams, to massive gravity dams like Hoover and Grand Coulee, it is obvious that the component materials normally used to make concrete cannot be arbitrarily or empirically blended. The day of casual reference to concrete as "mud" is past. Defining quality by allusions to 1-2-3, 1-2-4, or 1-2$^1/_2$-5 mixes or to 2,000, 3,000, or 5,000-lb compressive strength concrete is also obsolete. The old, though still rather prevalent, conception of concrete as essentially a hardened cement paste containing sand and stone for an economical inert filler is giving way to the realization that economy is a complex factor and that sand and stone are far from inert in their effects upon concrete structures.

The approach to effective design of a concrete mixture should be with the realization that the number of potential variables is infinite. The demands that will be placed upon the finished structure and the means by which it is to be constructed must be closely studied so that the proper choice of materials can be made. It may be a thin-walled water-retaining structure in a mild climate where design efforts should be centered upon watertightness; it may be an ornamental highway bridge in a severe climate where appearance and durability are of prime importance; it may be a massive gravity dam where the minimizing and control of internally generated heat are the prime factors; or, it may be a suspended floor slab in a factory where lightness and resistance to abrasion and bending are the prime requisites. Each structure in each locality presents its individual problems, and the factors of mixture design should be attacked accordingly.

After becoming thoroughly familiar with the nature of the project to be constructed, the first step of the mix designer is the choice of the water-cement ratio (*W/C*). This choice should be made with particular discrimination, because the water-cement ratio is the crux of the design and should be the single fixed factor upon which ultimate control is based. It will govern the strength that will be developed with the particular cement used; and it will materially affect the porosity, density, volumetric stability, and ultimate durability of the hardened concrete. Finally, it is an index to the relative economy of the mixture—the cost of ingredients and the facility with which the mixture can be consolidated into place.

Fortunately, the choice is simple. Reversing the usual philosophy, the *W/C* should be the highest value, within the range 4.5 to 7.5 gal per sack of cement, commensurate with the demand for density and durability. All too frequently engineers choose an unnecessarily low water ratio in the belief that they will get superior quality because of higher compressive strength. That is not always the case. As the water ratio is lowered, the unit quantity of cement is increased, because, for any one condition of mixture consistency, the two factors are roughly complementary. In other words, a certain amount of water-cement paste is requisite to a particular condition of placement and type of aggregate; therefore, as the unit water content is reduced the unit cement content is automatically increased.

Circumstances undoubtedly alter cases, but, in general, the use of more than the optimum quantity of cement is objectionable economically and structurally. Cement is the binding medium and prerequisite to the integrity of the member, but it is also unstable. With hydration, it generates considerable heat with attendant expansive tendencies and inevitable compensatory contractive tendencies; it is subject to attack by aggressive waters; it has a relatively high coefficient of thermal expansion and reacts readily in volume to moisture changes. In short, it is the weakest of the solid ingredients of concrete and should be kept at a practical minimum, which, for any given situation, is called the "optimum" quantity.

The second step toward mixture design is the selection of cement—a problem that becomes more and more complex as the number of types and specifications for portland cement continues to increase. The remainder of this article will deal with factors bearing on this selection.

Recent years have seen the development of cements designed for use under special conditions, particularly for minimizing the rate of heat evolution and increasing resistance to attack by sulfate-bearing waters. Since the Hoover Dam studies made engineers "heat conscious" the market has been flooded with alleged "low-heat cements" and admixtures with magical powers. Technical and pseudo-technical literature is filled with allusions to pozzolanas, synthetic pozzolanas, diatomaceous earths, fly ashes, natural cements, and high-silica cements. There has been a "heat wave" in the industry, and we are only gradually recovering from it. Out of the myriad claims and cure-alls, a few salient facts were gleaned and are becoming established.

CHEMICAL STRUCTURE OF PORTLAND CEMENT

A brief review of the chemical structure of portland cement seems advisable before discussing its physical reactions. The raw materials used in the manufacture of portland cement are limestone, clay (or marl), and gypsum. The first two provide the essential calcium and silica, and the third controls the rate of their initial reaction when brought into contact with water. Even high-lime limestones and high-silica clays contain other minerals—principally alumina, iron, and magnesia. Therefore, all portland cements contain the oxides of five minerals in important amounts. They are, silicon dioxide (SiO_2), calcium oxide (CaO), aluminum oxide (Al_2O_3), ferric oxide (Fe_2O_3), and magnesium oxide (MgO). When these oxides are burned at a temperature of about 2,700 F and properly cooled, they combine to form the four major compounds of portland cement: tri-calcium silicate, di-calcium silicate, tri-calcium aluminate, and tetra-calcium alumino ferrite.

The extent to which these major compounds are formed is a function of the temperature at which burning takes place, the time of burning, the nature of the burning process, and the manner and rate of cooling the clinker; and their presence can be determined quantitatively only by means of microscopic examination or X-ray diffraction. So far, such examinations are restricted to advanced research laboratories. True, to meet the popular demand a set of empirical formulas was devised that permits the calculation of the compounds from the oxides present in the cement. However, the very general use of these calculations is unfortunate because they determine finite figures from potential values. A rather far-fetched instance of the potential fallacy of this system of calculation was recently cited by Thaddeus Merriman, M. Am. Soc. C.E. He said, "Let us make a mechanical mixture of lime, of precipitated silica, of alumina, of ferric oxide, and of gypsum. We now grind these components finely together and give the resulting powder to the cement chemist who will report the oxides just as they were put into it. From these oxides he will then 'compute' the compounds and report them as being present. But we who made the mixture know that they are not there! They never were and they cannot be." This serves to illustrate the dangers of blind adherence to a mere theory without guarding the judgment by constantly keeping the limitations which surround the theory in the forefront of the mind.

Other compounds are present in cement in small amounts, but they will not be dwelt on here. The four principal compounds may be placed in two complementary groups, as follows:

Average Quantity	Common Symbol	Chemical Formula	Name
65–75%	C_3S	$3CaO.SiO_2$	Tri-calcium silicate
	C_2S	$2CaO.SiO_2$	Di-calcium silicate
20–30%	C_3A	$3CaO.Al_2O_3$	Tri-calcium aluminate
	C_4AF	$4CaO.Al_2O_3.Fe_2O_3$	Tetra-calcium alumino ferrite

The first group—the calcium silicates—normally constitutes about 70 per cent of the cement. The relation of one to the other (C_3S to C_2S in per cent) is a function of the time and heat of burning the cement clinker and the ratio of CaO to SiO_2. The latter group—the alumina and the iron compounds—normally constitutes another 25 per cent of the cement. The relation of one to the other is a function of the amount of alumina and iron present in the raw materials from which the cement is made. Under the old standard specification for portland cement, these four compounds varied considerably, but the average constitution was about 50 per cent C_3S, 20 per cent C_2S, 13 per cent C_3A, and 12 per cent C_4AF.

Studies of the four compounds have established their individual characteristics to be, briefly, as follows:

(*a*) Tri-calcium silicate is the principal contributor to early strength and to heat evolution. Its hydration, in the continuous presence of water, is essentially complete after 28 days.

(*b*) Di-calcium silicate is the principal contributor to late strength gain and late heat evolution. Its hydration does not commence until about 14 days after mixing and continues indefinitely as long as water is present. Cements containing large amounts of C_2S shrink more on drying than cements low in C_2S. This is due, probably, to the incompleteness of hydration of the C_2S at the time the concrete is permitted to dry.

(*c*) Tri-calcium aluminate contributes moderately to strength gain during the first seven days. During this time, C_3A evolves heat at a rate more than twice as great as C_3S. It is responsible for considerable expansion and contraction in hydrating cement, and is the compound most affected by contact with aggressive waters.

(*d*) Tetra-calcium alumino ferrite contributes little to strength, heat, or volume change.

CONTRIBUTION OF COMPOUNDS TO HEAT EVOLVED

The approximate contribution of the compounds to the heat evolved during cement hydration is shown in Table I.

TABLE I. APPROXIMATE CONTRIBUTION OF CEMENT COMPOUNDS AND SURFACE AREA TO HEAT OF HYDRATION

Element	Calories per Gram: 2 Days	7 Days	28 Days
C_3S	1.0	1.14	1.25
C_2S	0.0	0.21	0.42
C_3A	1.5	2.44	2.32
C_4AF	0.4	0.20	0.11
Surface area*	2.0	2.20	2.00

* For each 100 cm^2/gm in excess of 1,200 cm^2/gm of surface area, multiply by the factors shown for contribution to heat of hydration.

A natural inference from the characteristics of these compounds would be that cements should be made so as to contain only the calcium silicates. Unfortunately, this is impracticable of achievement. However, by carefully controlling the chemical oxide composition of the cement its behavior can be closely predicted, and by regulating the relative amounts of the oxides the rate of heat generation, volumetric stability, and resistance to chemical attack may be regulated.

The C_3S and C_3A are the principal contributors to heat generation and they are both susceptible to chemical attack. Therefore, their reduction is most essential when conditions indicate the necessity for low heat generation or high resistance to chemical attack. The C_3S content can be reduced by the addition of silica to the raw materials, and the C_3A can be reduced by the addition of iron oxide. The extent to which these additions are required must be judged with caution, because, in the case

AN OBJECT LESSON IN GOOD VERSUS POOR WORKMANSHIP

This Bridge, Built in 1902, Is in Perfect Condition After 37 Years Severe Exposure to Frost Action. The Retaining Wall Abutting It, Built in 1926 of Similar Materials, but with Inferior Workmanship, Is Already in a Serious Stage of Deterioration

of the calcium silicates particularly, heat and strength are closely allied. In other words, the reduction in heat generation coincident with a reduction in the C_3S content, and consequent increase in C_2S, is accompanied by an inevitable reduction in early strength gain. In the case of C_3A, which is complementary to C_4AF, the addition of iron reduces the C_3A content by building up the C_4AF. Since the latter contributes little to the desirable qualities of cement, there is no point in overly increasing it. Also, the addition of an excess of iron makes probable the formation of C_2F, which is undesirable.

Modifications in the chemical structure of cement, therefore, must be made only to the extent demanded by the particular structure in mind. The gravity sections of massive dams usually require no high early-strength gain, and the reduction in C_3S and C_3A can be to a maximum to minimize temperature rise. On the other hand, the thinner sections of the same dam (such as the power house structure) require a fair degree of early strength, and reduction in the C_3S content would be definitely detrimental. Again, a structure of normal size exposed to attack by strong alkali waters would demand a minimum C_3A content and a C_3S content high enough to permit efficient progress and early form stripping. However, for about 75 per cent of all concrete construction, it is not necessary to alter radically the normal chemical structure of cement to avoid deleterious effects.

SPECIAL PORTLAND CEMENT SPECIFICATIONS OF THE FEDERAL GOVERNMENT

The federal government has recently issued four portland cement specifications which cover the requirement for special cements. They are briefly described as follows:

(a) SS-C-191a might be called the new standard specification for portland cement. It differs from the old standard mainly in a requirement for more rigid control of the product. This cement is suitable for normal building construction and for non-massive structures not exposed to appreciable climatic or chemical attack. The C_3A limit of 15 per cent is high. The average composition under this specification would be about 50 per cent C_3S; 20 per cent C_2S; 13 per cent C_3A; 12 per cent C_4AF.

(b) SS-C-206 is the specification for "moderate heat of hardening" cement. The chemical and physical requirements are such as to make the cement moderate in its heat generation; it is high in resistance to climatic and chemical attack, and satisfactory in its rate of strength gain for all ordinary purposes. In addition, the requirement for fineness is such as to make it excellent for workability and plasticity. The chemical and physical control is rigid without imposing a serious handicap on the manufacturer. The average compound composition for this cement is about 40 per cent C_3S; 30 per cent C_2S; 7.0 per cent C_3A; 15 per cent C_4AF. (This cement is very similar to the 15-C cement used by New York State and is the type generally used by the Corps of Engineers in flood control work in the Northeastern United States.)

(c) SS-C-211 is known as a sulfate-resisting cement and is designed for use in cases where attack by alkali- or sea-water is expected to be particularly severe. The chemical composition of this cement also places it in the semi-low heat group. The average composition of cement made under this specification would be about 35 per cent C_3S; 35 per cent C_2S; 4.0 per cent C_3A; 18 per cent C_4AF.

(d) SS-C-201 is known as a high early strength cement. It is designed for use in structures which must be placed in service in the shortest period of time and where exposure to climatic and chemical attack will not be severe. There are different methods for achieving the high early strength required, but the two principal methods are: (1) very high C_3S content and moderately high fineness, or (2) very high fineness and normally high C_3S. An average composition would be about 60 per cent C_3S; 10 per cent C_2S; 13 per cent C_3A; 12 per cent C_4AF. High early strength cements are manufactured with C_3S contents as high as 72 per cent and with no C_2S, and others with C_3S contents of 50 per cent with extremely high fineness.

In view of the comments on regulating the composition by varying the silica and iron content, it might be interesting to review the requirements for these minerals in the four specifications just described. In this connection see Table II.

TABLE II. CHEMICAL REQUIREMENTS AND SURFACE AREA REQUIREMENTS—FEDERAL SPECIFICATIONS FOR PORTLAND CEMENT

Specification	SiO_2 (Silica)	Al_2O_3 (Alumina)	Al_2O_3/Fe_2O_3 (Alumina-iron Ratio)	C_3A (Tri-calcium Silicate)	Fe_2O_3 (Iron)	MgO (Magnesia)	SO_3 (Sulfuric-anhydride)	Surface Area (Cm^2/Gm)
SS-C-191a	..	−7.5%	.....	−15.0%	−6.0%	−5.0%	−2.00	+1,500
SS-C-206	+21%	−6.0%	0.7 to 2.0	− 8.0%	−6.0%	−5.0%	−2.00	+1,800
SS-C-211	+24%	−4.0%	0.7 to 2.0	− 5.0%	−4.0%	−4.0%	−1.75	+1,800
SS-C-201	..	−7.5%	.....	−15.0%	−6.0%	−5.0%	−2.50	+1,900

Note: A minus sign indicates "not more than"; a plus sign, "at least."

Specifications SS-C-191a and SS-C-201 have no limiting requirement for silica, which indicates no particular attempt at heat or chemical attack control. The limit of 7.5 per cent for the alumina is high enough to obviate the necessity for adjusting the normal raw materials by the addition of iron. Except for the requirement for fineness and strength, the two specifications are very similar.

The moderate heat cement (SS-C-206) requires a minimum of 21 per cent silica and a maximum of 6.0 per cent alumina. Protection from an excess of iron is given by a special limiting of the iron and the alumina-iron ratio. These limits require the addition of silica and iron

to the raw materials available to a considerable proportion of the cement mills in the United States.

The sulfate-resisting cement (SS-C-211) requires a minimum of 24.0 per cent silica and a maximum alumina content of 4.0 per cent, with protection against the inclusion of excessive iron. The amount of silica and iron normally required to bring the average supply of raw materials within these limits makes the manufacture of this cement difficult and expensive. For this reason the specification is used only for unusual cases.

There are two minor but important constituents of portland cement which deserve at least brief mention—magnesia and free lime. Magnesia enters cement as extraneous matter in the raw material. If present in large amounts, it will cause delayed expansion and cracking of a serious nature in the finished concrete. However, magnesia is limited to not more than 5 per cent in all modern specifications. Free lime is that portion of the original lime in the raw materials which has not been combined with silica or iron or alumina during the burning process. The particular significance of its presence in amounts greater than 1 per cent in finished cement is an indication of incomplete burning.

The rigidity of the special specifications for cement (SS-C-206,211,201) requires a very much more careful analysis and examination of the product than has been necessary heretofore.

NON-PORTLAND TYPES OF CEMENT AND THEIR USES

In completing the discussion of cement it would be well to discuss briefly certain of the non-portland types which are often advocated to minimize heat generation or increase resistance to deteriorative forces. These materials and cements are used usually as blends—that is, as replacements for a certain portion of the portland cement normally required for a particular mixture. They are used rarely as the sole cementing material.

Most prominent of these types are the pozzolanic cements—a large and ever-increasing family. The original pozzolana was a volcanic ash found in the province of Pozzuoli in Italy. The chemically active siliceous ash when mixed with lime and water would combine to form an insoluble calcium silicate of considerable cementing quality. This was probably the famous cement of the ancients. From the action of this original material, "pozzolanic action" has come to connote the ability of any chemically active silica to react at normal temperature with lime and water to form an insoluble calcium silicate. The chemical reaction takes place very slowly, in the presence of water, with a correspondingly slow gain in coherent strength and slow evolution of heat during the hydration period. The speed demanded in modern practice prohibits the use of pozzolanas as the sole cementing medium, but they are often advocated as additions to or partial replacements for portland cement on the dual premise that they will react with the calcium hydroxide liberated from hydrating C_3S to form calcium silicate, and that they will lessen the rate and amount of temperature rise in concrete.

Next in importance are the natural cements. These are manufactured from argillaceous limestones, which contain silica, lime, alumina, iron, and magnesia. Burning this cement rock at a relatively low temperature dehydrates and activates the constituents and, after grinding, provides a hydraulic cement somewhat similar to portland. Usually the silica content is high and the lime content quite low; therefore, with burning at a lower temperature than that used for portland cement, no C_3S is formed—only CS and C_2S. Before the rise to prominence of portland cement with its early strength gaining property, natural cements were generally used throughout the country. There are a number of excellent structures in use today, which were built with them as much as 100 years ago. Today they are rarely, if ever, used alone, but there are cases where natural cement is used as a replacement for a portion of the portland cement, either to minimize temperature rise or to increase resistance to deteriorative forces.

Natural cements vary markedly in their composition and correspondingly in their strength-gaining and durable properties.

Alumina cement ("Lumnite") is a third type of non-portland cement particularly worthy of mention. Lumnite is a type unto itself and is made from limestone and bauxite ore. It contains the five minerals found in natural and portland cements, but in very different proportions. It is very low in silica and has only about one-half the lime usually found in portland cement, but is quite high in alumina and iron. That its compound structure is at all similar to that of portland cement is doubtful, but, for purposes of analogy, it may be said that CA (monocalcium aluminate), C_2S, and C_2F are the principal compounds. The absolute absence of C_3S and C_3A may explain why alumina cement has none of the susceptibility to alkali attack found in portland cements containing considerable amounts of alumina.

This cement is the most rapid strength gainer of all hydraulic cements, reaching about 90 per cent of its ultimate strength in 24 hours. Moreover, its ultimate strength, for an equal W/C, is greater than that of any other hydraulic cement, and it is practically impervious to attack by the aggressive waters which are the enemies of portland cement. From this eulogy it would appear to be a paragon. Unfortunately it has two distinct disadvantages—cost (it is about $3^1/_2$ times as expensive as portland cement), and heat. The rapid evolution of heat is capable of destroying cementation if the heat is not permitted to escape rapidly.

Lumnite cannot be mixed or blended with portland cement. If this is attempted, a "flash" set will occur with immediate and inefficient hardening of both materials. Used in thin sections, where immediate and high strength or strong resistance to chemical attack is essential, Lumnite cement has distinct merit.

CONDITIONS DEMANDING SPECIAL CEMENT TREATMENT RELATIVELY FEW

This discussion of cements may be summarized by the statement that the conditions which demand special cement treatment are relatively few. At the present stage of technical knowledge of portland cement, tampering with the chemical constitution imposes a hardship upon the manufacturer without sure compensatory benefit. Greater and more certain benefit may be derived from the intelligent choice of cement quantity than from unenlightened meddling with composition quality. If fear arises as to excessive temperature rise, use an intelligent minimum of cement and provide for a maximum opportunity for dissipation of the heat. If durability, watertightness, and sightliness are paramount, strive for maximum density and efficiency of placement and curing. All of these things can be and are being achieved with portland cement without recourse to blends or major cement modification. If the quality of concrete could be reduced to proportional influences of the factors which enter into its manufacture, it might be possible to state the case as follows: workmanship, 70 per cent; aggregate, 15 per cent; and cement, 15 per cent.

Notes on the Hydraulic Jump

Its Uses and Characteristic Occurrences; Reasons for Its Failure to Occur Where Expected

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Very useful and very perverse is the hydraulic jump. It can dissipate energy, recover head, increase orifice discharge, or serve as an aeration device. But sometimes it fails to appear where looked for, with serious consequences; and again it may put in an unexpected appearance with equally disastrous results. Mr. Scobey's notes on this interesting phenomenon point out the reasons for these vagaries, and contain many suggestions that should make for better hydraulic design. This paper was on the program of the Hydraulics Division at the Society's 1939 Spring Meeting.

At present the hydraulic jump is used extensively to dissipate unwanted energy of rapid - flowing water. However, there are some misunderstandings regarding the jump, and much theoretical and empirical research remains to be done. Many structures have been built where the jump, though expected, did not occur, or at best occurred imperfectly. Too often it was believed that shooting flow injected into or against streaming flow must necessarily lose its energy through the jump. That it may not do so is shown in two of the accompanying photographs. Other pictures show jumps in very imperfect form, and several waves that may be easily mistaken for the jump.

The following notes are based on the writer's observations of the hydraulic jump over a long period of years. Some of them are marked with an asterisk; these are believed to be valid, but are possibly in error and are subject to demonstration and proof.

Uses of the Jump:

1. To dissipate energy—from a thin, fast sheet. All the energy is seldom lost.
2. Paradoxically, to recover head—up to 75 or 80 per cent from a "fat" jet (Fig. 1). All the energy cannot be recovered. There must be some loss.
3. As a mixer of chemicals—doses for water purification, and so forth.
4. As an aeration device for city water supplies.
5. To increase weight on an apron and reduce uplift, by causing streaming flow at greater depth while still on the apron, as near the overpour as may be.
6. To increase the discharge of an undershot orifice, by holding back tailwater. (The effective head is reduced if the tailwater is allowed to submerge the jump.)
7. As an indicator. The presence of a jump means a definite break in the energy gradient; it follows that

(*a*) The flow upstream must have been at shooting, or rapid, stage.

(*b*) To reach rapid stage, if developed over a crest, then the important critical depth must have held near this crest.

(*c*) If flow issues from an orifice or from under a sluice gate, then critical velocities are not present, the jet issuing from a tranquil pool directly as shooting flow.

(*d*) Returning to (*b*), if critical flow holds at a crest, then tailwater stage, below the jump, has no effect on the discharge over the crest.* The crest discharge is thus already a maximum for the conditions of contraction, crest roughness, and available head; and therefore a good place to form a basis for computations.

(*e*) No backwater effect travels upstream in shooting flow. The velocity of a pressure wave is that of the velocity at critical depth, and shooting flow is faster than critical—hence, faster than the velocity of the wave.*

(*f*) With the criterion of the jump, a crest upstream may be used for measurement of the flow, as over "falls" in India and through the Parshall flume. Similarly a current-meter gaging station just above a jump is free from channel changes below the jump and any resulting change of stage through the gaging station (Fig. 2).

When the Jump Can Be Expected (Usual Cases):

1. Flow over a dam crest and down a very sharp incline, turning towards an approximate horizontal into a pool whose surface lies just below the upper alternate stage of the overpouring discharge below the dam.
2. Flow down a channel at velocity faster than critical, impinging into a pool whose surface is as in (1) above.
3. Flow under a gate shutter, at a velocity faster than critical for the channel below the gate, impinging as in (1) above.
4. Vertical fall to level or sloping smooth surface. Sheet flows radially from place of impingement, both uphill and downhill. Jump occurs as a fringe around a thin, transparent, non-turbulent sheet.* As the tailwater beyond the jump deepens, the jump is driven toward the fall until finally the jump disappears and the energy of the fall is dispersed in a general tumultuous

Fig. 1. In This Jump (Far End of Flume) Some 80 Per Cent of the Head Is Recovered

The View Is Taken Looking Downstream Through Flume at Shooting Velocity; Water in Distance Jumps to Tailwater Level. Needle Boards in Far Distance Have Been Adjusted to Hold Jump Just at Outlet of Flume—That Is, at Stage of Maximum Recovery of Velocity Head

water cushion. This sequence can be followed in any lavatory washbowl. Note the complete lack of turbulence of the jet in radial flow. Submergence can be controlled with the stopper.

When the Jump May Occur Where Unexpected:

1. In a sinuous canal of uniform shape, designed for a velocity just under the critical. The initial canal surface may have a lower value of *n* than used in design; the velocity may gradually race to exceed the critical. The obstruction of excess curvature or of a backwater condition may throw the flow through the jump. If done by curvature, the flow may race, following the jump, until again exceeding the critical.

2. Whenever excess fall is provided in any one part of a variable channel, then flow faster than critical is quite likely to develop. When the excess fall has been absorbed by the losses due to excess velocity, then the flow will pass through the critical to tranquil, approximating that of the normal in the section where the change occurs. The change of stage will usually, but not necessarily, take place through the jump. Specific cases follow.

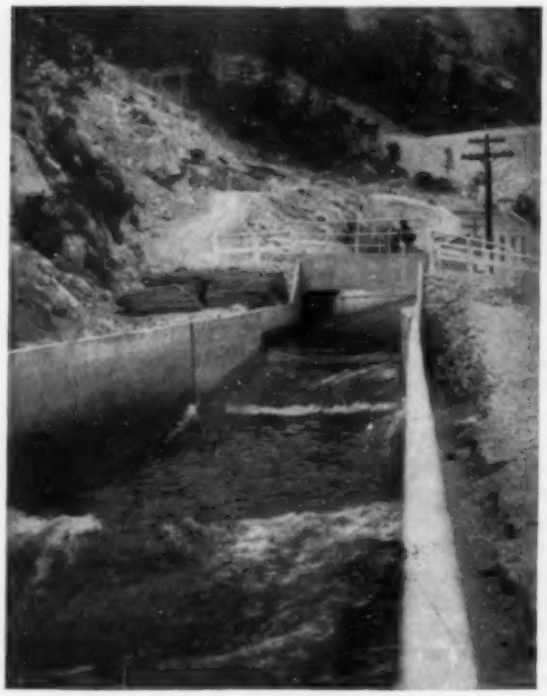

FIG. 2. HYDRAULIC JUMP USED TO ENSURE CONSTANT STAGE-DISCHARGE RELATIONSHIP AT GAGING STATION

This Current-Meter Gaging Station (Visible Under and Beyond the Bridge) Was Subject to Variation of Stage for Same Flow, Due to Algae Growths at Different Times of Year. Installation of the Control Structure This Side of the Bridge Causes Flow to Pass Through Critical Depth Somewhere Along the Uniform Throat Section; the Resulting Break in Gradient Assures Stages at the Meter Station Independent of Stage in Flume Below

3. Where a constriction, such as a flume, is designed for a material increase in velocity from a feeder canal but the actual flow is considerably less than the design flow. The excess fall provided for a greater flow will speed the water more than necessary in the constriction. If there is enough excess fall, the increased velocity will exceed the critical. To get back to constriction stage, the jump will be abrupt if there is an abrupt change between canal and constriction. If the transition is well streamlined, the jump may conform to Bakhmeteff's "undulating jump" (Fig. 3).

4. In past years, many flumes were built with a steep incline at the intake end. This resulted in shooting flow being generated. If the flume was classed as a "short" structure, the rapid flow sometimes held throughout its length, with a jump at the outlet transition. In a "long" flume, the jump occurred when the high velocity could no longer be sustained by an insufficient slope. The exact location of the jump cannot be predicted. It can be computed, but the computations involve assumptions of the friction factor that can hardly be known with enough exactness to trace the water stages in either shooting or tranquil flow. Thus, V_1 and V_2 are in doubt in the computations. This doubt is carried into the momentum curves used to indicate the location of the jump.

5. Flow down pipe chutes may occupy part of the cross-section at a very high velocity. If the grade is uneven, or slug flow develops, then the whole pipe section will "plug," as by a jump, and the flow will occupy the whole pipe section back to the intake structure. The "plug" may take place several hundred feet down the chute. The filling of the pipe, back upstream, is almost instantaneous.

6. A similar condition may develop in a lined tunnel. If waves slap the roof, plugging may take effect; the wetted perimeter immediately increases by the length of the roof line, the value of the hydraulic radius falls, and the whole flow plugs the tunnel and may be reduced in quantity. Of course, any excess oncoming water that cannot enter the tunnel may overflow the banks above the tunnel inlet.

Where the Jump Develops Partially or Not at All, Although Expected (This condition is generally associated with very steep channels—that is, inclined drops set at slopes in excess of those used for most chutes):

1. Where the discharge is into a pool and the incline continues without change until deeply submerged. Here the jet dives beneath the pool, with but a very small roller. Final dissipation of energy is indicated in boiling fountains and general eddies, out in the pool, many feet below the incline (Fig. 4). At moderate submergence a "submerged jump" may take place. Effective dispersion of energy is questioned.

2. Like (1) except that the incline turns towards the horizontal below the tailwater level. There are three cases under this heading:

(*a*) If tailwater stage is above the upper alternate stage after deducting loss in the jump, then only partial development occurs, and final dissipation is only slightly more definite than described in (1) just above.

FIG. 3. AN UNDULATING JUMP

Flow in Foreground Has Just Exceeded Critical Velocity. The Perfect Transition Does Not Afford Any Abrupt Point for the Jump to Occur

(b) If tailwater is shallower than the stage to which full jump would carry the jet, then the water shoots back through the surface (Fig. 5) or scoots over the surface of the tailwater, the jump developing more and more perfectly as the next case is approached.

Fig. 4. Jet Diving Beneath Pool; the Energy Is Dispersed in Great Boils Many Feet Out in the Forebay

(c) If tailwater is at such level that the upper stage, after losses, will agree with the pool surface at any point along the horizontal or gently sloping floor, then a pure jump will occur.

Bakhmeteff and Matzke have carried experimental work and analysis as far as the maximum slope they could develop at Columbia University ($S = 0.070$). This research is reported in their paper on "The Hydraulic Jump in Sloped Channels" (*Transactions*, A.S.M.E., February 1938, p. 111). Likewise, Rindlaub ("The Hydraulic Jump in Sloping Channels," unpublished thesis by Lt. Bruce D. Rindlaub, U.S.A. College of Civil Engineering, Graduate Division, University of California) had a steeper incline, but did not have a pool of great depth. In other words, the jet could shear under the tailwater, but was turned towards the horizontal very quickly and would then jump. There remains much research work on slopes found in field construction—down slopes up to 100 per cent (1 on 1) and with the slope controllable under the tailwater so that many combinations can be developed.

Fig. 6. Flow Passing from Shooting Stage (in Foreground) to Streaming Stage Without Evidence of a Jump

From the 5-In. Planks on the Side, Note That Surface Rise Is Nearly 10 In.

Remarks:

In a uniform canal a trash rack may cause so much loss of head that the stream below is at shooting stage, returning to normal flow through the jump.

It is not advisable to install a vertical drop in a uniform canal whose normal flow is faster than critical. A tumultuous smother of water results. It is better to throw the flow through the jump to the tranquil stage and then drop the water over the brink.

Shooting flow cannot well be gradually slowed down. No backwater curve can develop because the velocity of the water is faster than the velocity of the pressure wave necessary to the backwater curve.* Slowing down is usually abrupt through the jump. Thus, two sections of uniform canal, both at slopes steeper than critical, but the first section much steeper than the second, will have shooting flow down the first section, while the flow may jump below the foot of the steeper slope because the second section is not steep enough to convey the flow at the velocity generated at the foot of the steeper slope. The only case ever noted by the writer of flow passing smoothly from shooting to streaming was in a uniform channel for which the momentum-plus-pressure curve (for any constant Q approaching capacity flow) had a blunt apex at critical depth. For about one-half foot below and above critical depth, the curve and a chord were almost coincident. When observed, shooting flow changed to streaming flow in a smooth rising swell some 0.7 ft high without any indication of the jump (Fig. 6).

Fig. 5. Mere Impingement of Shooting Flow Into a Pool Does Not Ensure the Jump

Here the Impinging Stream "Pops Up" Through the Pool Surface and Rushes on Down the Canal; the Desired Disbursement of Energy Has Not Taken Place. Note the Riprap, Placed After Apron Proved Inadequate. Downstream from the Riprap, Heavy Erosion Still Continued

Avoid a perfectly horizontal flow in a uniform channel if the jump is desired. Otherwise, the location of the jump will always be uncertain because the computer cannot be sure of his friction values. The slope allows the necessary balance between the pressure-momentum of rapid flow and that of tranquil flow to develop somewhere along the incline.

The hydraulic jump does not occur at a point but over a definite length. A true jump is under a surface roll that extends throughout this length.

The law of conservation of momentum permits a satisfactory analysis of "standard" clean-cut jumps.

Earthquake Studies for Pit River Bridge

By J. L. Savage

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Design of the Pit River Bridge, with its concrete piers 360 ft in height, called for a painstaking study of the possible effects of earthquake. Fundamental investigations were undertaken along a number of lines, and numerous stress analyses of the proposed structure were made, based on actual accelerometer records obtained during quakes whose destructive intensity is a matter of record. This work, says Mr. Savage, has led to new conceptions of earthquake effect and to better design methods. The present article, which was on the program of the Structural Division at the 1939 Annual Convention, is a brief synopsis of the methods employed and the results obtained in these investigations.

Construction of Shasta Reservoir, a unit of the Central Valley project in northern California, involves the relocation of the Southern Pacific Railroad and of U. S. Highway 99. The relocated railroad and highway will cross the Pit River arm of the reservoir on a double-deck, steel cantilever bridge that requires concrete piers of 360-ft maximum height and of over 300-ft submerged height (Fig. 1). These high submerged piers, as well as the steel superstructure, have been designed with due regard to earthquake effects, which are found to have an important bearing on the stresses.

The early discussions of earthquake effects in their relation to the design of the Pit River Bridge led to the following tentative conclusions:

1. The effect of submergence of the piers should be considered.
2. The assumption of a fixed percentage of gravity as a measure of earthquake intensity may give adequate strength in parts of the structure but entirely inadequate strength in other parts.
3. A better criterion would be to use the accelerograms of actual earthquakes and investigate mathematically the effects of these earthquakes on the structure.
4. The mathematical investigations should not only be based on the assumption of elastic action but should also consider the case of a pier rotating at the base.

As a result of these tentative conclusions three fundamental investigations were undertaken as follows: (1) The effect of submergence on the apparent or virtual mass of a pier; (2) earthquake effects in a bridge on elastic piers fixed at the base; and (3) the stability of a rigid pier rotating at the base. These investigations have led to new conceptions of earthquake effect and to better design methods. They explain why piers and similar structures, although not originally designed to withstand earthquakes, are often little affected by them. They show that if actual recorded earthquake acceleration intensities are applied as a steady force to the Pit River Bridge piers, the resultant generally will fall outside the base, indicating failure. However, if this assumption were correct many bridge piers and similar structures in the vicinity of the Long Beach, Calif., earthquake of March 10, 1933, and of the Helena, Mont., earthquake of October 31, 1935, would have failed, which was not the case.

Mathematical analyses, supplemented by shaking-table investigations, lead to the conclusion that any lateral earth movement tending to tip the pier reverses its direction before the mass of the pier can follow such movement, and that this restoring effect takes place as soon as the lateral movement is of sufficient magnitude to throw the resultant force toward the edge of the base. Under these conditions the pier no longer behaves like an elastic structure fixed at the base. On the contrary, it acts as a rigid structure rotating at the base.

The design criteria that resulted from these studies can be summarized as follows for the Pit River Bridge:

1. Design the pier base with strength and stability for the usual lateral loads, such as wind and traction forces, without any consideration of earthquake effects.
2. Design the pier above the base for lateral earthquake forces of such intensity that the resultant is at the edge of the base. While these design criteria are for piers only, the investigations were extended to include the superstructure in its entirety.

Effect of Submergence on Virtual Mass of a Pier

The concept of virtual mass is very useful in the study of the forces acting on bodies which are being accelerated in a fluid medium. The general theory may be found in Horace Lamb's *Hydrodynamics*, and it will be sufficient here to state that the principle involves the determination of the total kinetic energy of the surrounding fluid due to the body's moving through it with a constant velocity. The kinetic energy depends on the density of the fluid, the stationary boundaries of the fluid, the shape of the moving body, and the direction of motion. It is important to note that the virtual mass will in general vary with the direction of motion. A body has three axes—"the axes of permanent translation"—and from the virtual mass in these directions it is possible to determine the additional virtual mass or inertia coefficients in any other direction. Conversely if the virtual mass is known, the total force exerted by the fluid upon the accelerated body is found by multiplying the virtual mass by the acceleration.

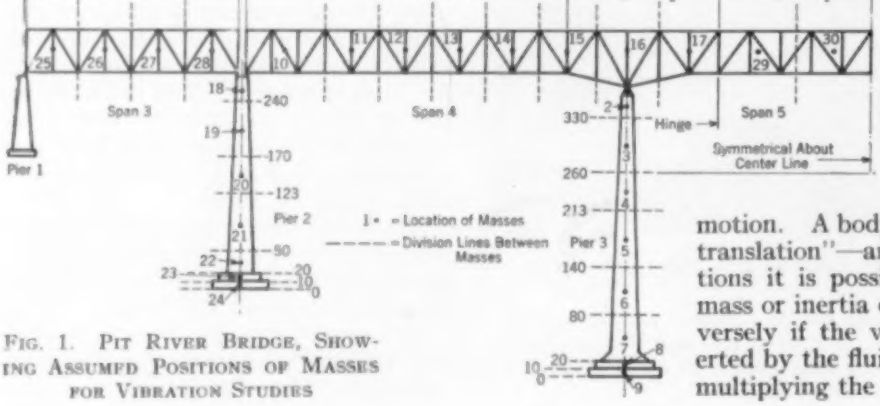

Fig. 1. Pit River Bridge, Showing Assumed Positions of Masses for Vibration Studies

The virtual mass may be found experimentally simply by letting a model of the body oscillate slowly as a pendulum, first in air and then in the fluid, and comparing the periods; it can also be determined mathematically in simple cases. As an example of the importance of this factor, it is of interest to note that the virtual mass for Pier 3, submerged and moving "broadside," is more than twice the mass of the unsubmerged pier.

In the case of a bridge pier of slightly varying width it has been found experimentally that the two horizontal principal additional virtual masses may, for practical purposes, be taken as the fluid contained in the circular truncated cones constructed over the broadest and narrowest vertical projections, respectively, of the pier. The additional virtual mass in any other direction is the sum of the vector projections of the two principal virtual mass vectors on the desired direction.

The vertical virtual mass to be used in the determination of the restoring moments for a tilted submerged pier under full uplift can safely be taken merely as the mass of the buoyed structure. The effect of skin friction on the behavior of a submerged pier must not be confused with the concept of virtual mass, but must be included in the equation of motion as a viscous damping effect. However, with the velocities and displacements involved in connection with pier displacements during earthquakes, it is doubtful if this damping is of great consequence. It would be on the side of safety to ignore it.

TORSION PENDULUM USED IN PIT RIVER BRIDGE RESEARCH

In the stability investigations of a submerged pier, considered as a rigid body, the concept of "virtual rotary inertia" also becomes of importance. For practical purposes, when small displacements are to be dealt with, the rotary moment of inertia about a line in the base plane perpendicular to the plane of rotation may with sufficient accuracy be taken simply as the polar moment of inertia of the total virtual mass.

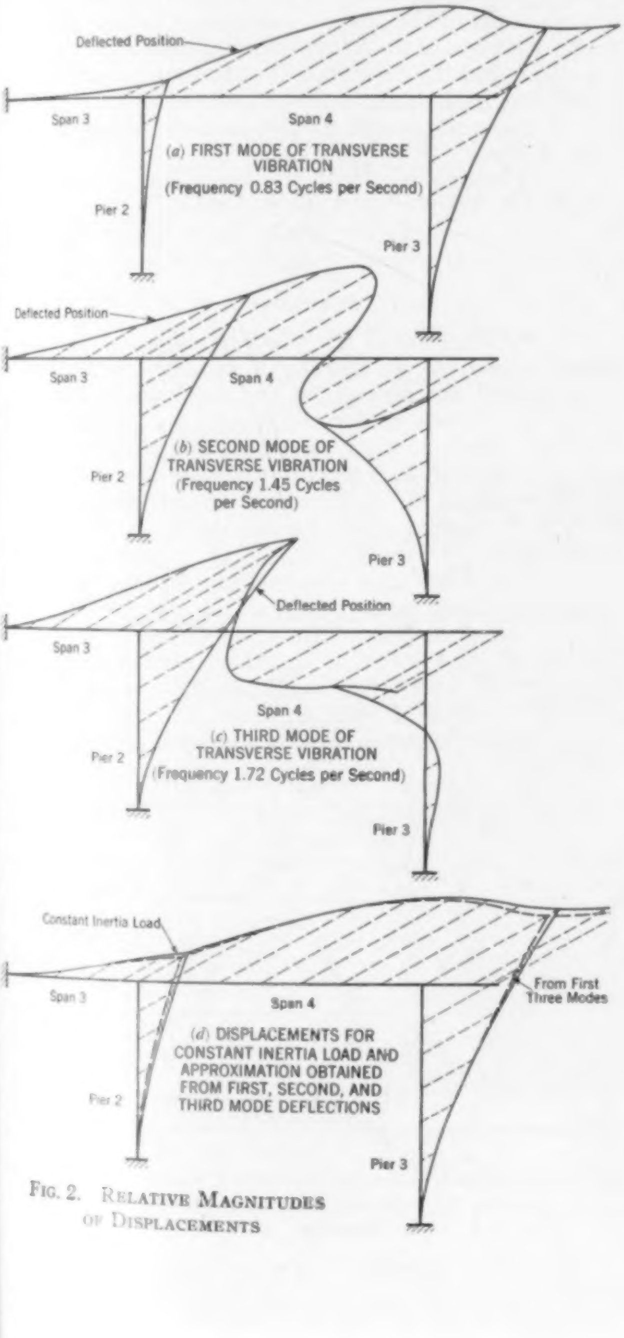

FIG. 2. RELATIVE MAGNITUDES OF DISPLACEMENTS

EARTHQUAKE EFFECTS IN A BRIDGE ON ELASTIC PIERS FIXED AT BASE

The method employed for judging the ability of this structure to resist earthquakes makes use of a computation of stresses based upon accelerometer records obtained during quakes whose destructive intensity is a matter of record. The earthquake records utilized for this purpose were from the Long Beach quake of March 10, 1933, the Helena quake of October 31, 1935, and the November 11, 1937, quake at Boulder Dam.

This investigation shows that a structure of the type described, when subjected to an earthquake, vibrates in a series of distinct or separate patterns or modes, each of which has its own characteristic frequency and is capable of being executed independently of all the others. If the structure is subjected to a steady transverse acceleration it will be bent into a certain pattern, distinct from the mode patterns, but the coefficients of the several modes are to be determined by fitting this pattern by a series of the modes in a manner similar to that employed in the development of a Fourier series. The amplitude of vibration in each mode during the quake is

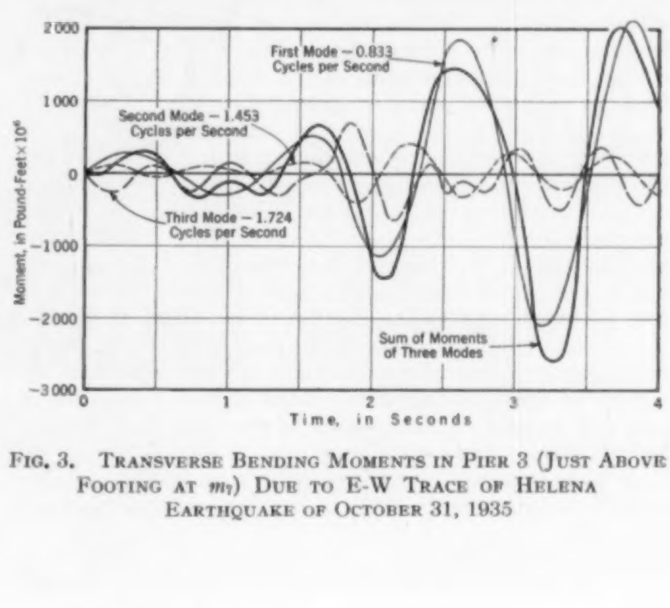

FIG. 3. TRANSVERSE BENDING MOMENTS IN PIER 3 (JUST ABOVE FOOTING AT m_7) DUE TO E-W TRACE OF HELENA EARTHQUAKE OF OCTOBER 31, 1935

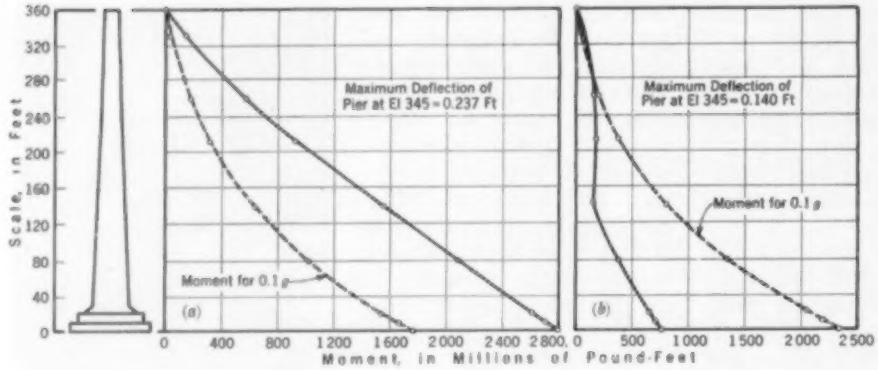

FIG. 4. MOMENT DIAGRAMS OF PIER 3, BRIDGE SUBJECTED TO (a) E-W TRACE OF HELENA QUAKE IN TRANSVERSE DIRECTION AND (b) N-S TRACE OF HELENA QUAKE IN LONGITUDINAL DIRECTION

proportional to a quantity determined by the natural frequency of the mode and the characteristics of the quake. These quantities can be calculated from the accelerometer record by a process of approximate integration, or obtained from experiments performed on a torsion pendulum. Displacement curves are required for operation of the torsion pendulum but these are readily

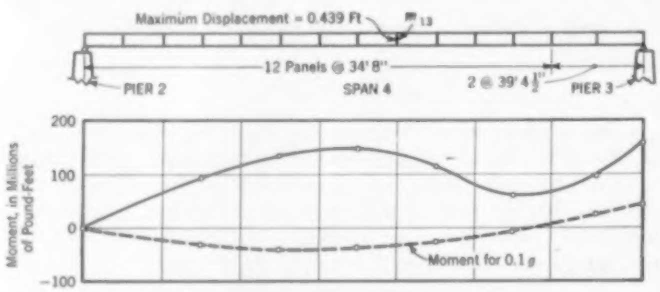

FIG. 5. MOMENT DIAGRAM OF SPAN 4, BRIDGE SUBJECTED TO E-W TRACE OF HELENA QUAKE IN TRANSVERSE DIRECTION

obtained from the accelerometer records by double integration.

Typical curves from these studies, which with the captions are self-explanatory, are presented here as Figs. 2 to 6.

STABILITY OF A RIGID PIER ROTATING AT THE BASE

It was found in the course of the studies that the restoring moment necessary at the section between the base and the foundation may become greater than can be delivered by the weight of the pier and the attached structures. For this reason the base plate will lift off the foundation to an extent depending on the dimensions of the pier, the magnitude of the ground displacement, and the frequency of the motion. Therefore, the analysis in which the pier is treated as a cantilever fixed at the base will be valid only if the pier is actually anchored to the foundation.

It is interesting to see what will happen if the crack is allowed to open. In order to investigate the stability in this case it is assumed that the pier shaft is absolutely rigid, and that it will begin to rotate about some line perpendicular to the motion of the foundation, and located in the base plane of the pier plate. The actual instantaneous axis of rotation can be determined as the center of the foundation reactions during the rotation, and will depend on the rigidity of the base plate and the foundation. The rotary moment of inertia about the base now becomes of major importance in the stability considerations, whereas it is of little importance, and as a rule entirely neglected, when the pier is treated as a flexible cantilever fixed at the base. The rotary inertia in itself will oppose the various impressed motions of the foundation so that the center of percussion will remain practically stationary during the quake.

The laws of mechanics governing rigid body translation and rotation about an axis lead to the conclusion that the stability of high piers is only slightly affected by earthquakes that have proved destructive to other types of structures. It is then only the question of strength which is involved. The forces that act on the various portions of the pier during the accelerated motion are very easily determined mathematically under the above-stated assumptions. It can be shown that the axis of rotation lying in the base plane will be sufficiently inside the edge of the base plate to keep the reactions well below the permissible bearing pressure on good rock foundation. In determining the extreme position of this axis for the maximum tilt of the pier, it is necessary to consider both the deformation of the base plate in compression, bending, and shear, and the deformation of the contact area of the foundation itself under normal and shear forces. This part of the work resembles the problem encountered in roller bearings.

An interesting result of the investigation should be mentioned—namely, that the maximum displacement at the top of geometrically similar piers during the same earthquake is practically independent of the height.

PERSONNEL

The investigation of the effect of submergence on the virtual mass of a pier and the investigation of the stability of a rigid pier rotating at the base under earthquake effects were made under the direction of Dr. J. H. A. Brahtz. The investigation of earthquake effects in a bridge on elastic piers fixed at the base was made under the direction of R. E. Glover. The structural designs of the bridge were prepared under the direction of Robert Sailer, Assoc. M. Am. Soc. C.E.

All engineering and construction for the Bureau of Reclamation are under the general direction of R. F. Walter, M. Am. Soc. C.E., chief engineer, and S. O. Harper, M. Am. Soc. C.E., assistant chief engineer, with headquarters at Denver. All activities are under the general direction of John C. Page, M. Am. Soc. C.E., commissioner, with headquarters at Washington, D.C.

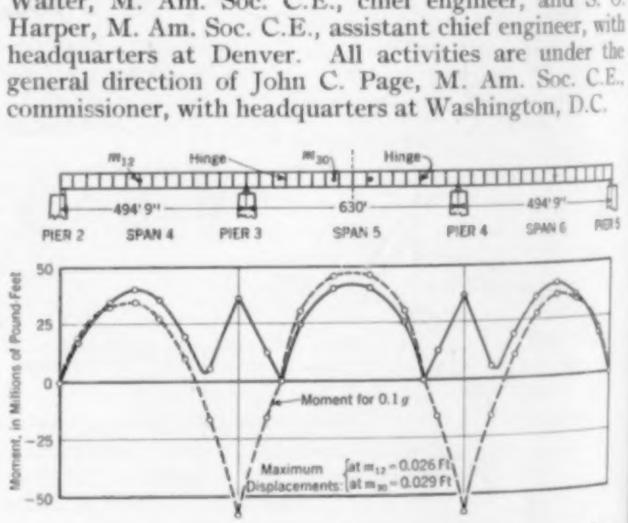

FIG. 6. MOMENT DIAGRAM OF SPANS 4, 5, AND 6, BRIDGE SUBJECTED TO VERTICAL TRACE OF HELENA QUAKE IN VERTICAL DIRECTION

Organization of TVA Surveying and Mapping Activities

By Ned H. Sayford

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Handling essentially all the surveying and mapping requirements of TVA is a single organization—the Maps and Surveys Division. Starting "from scratch" in 1933, its force had reached a peak of 450 by 1936. Its operations have extended over 40,000 sq miles, and have included surveys of all types—control, construction, property, topographic, and hydrographic. Speed, without sacrifice of accuracy, has been paramount at all times. An organizational set-up that would provide a maximum of flexibility, eliminate duplication of work, and turn out products of uniform, appropriate accuracy in all branches, was essential. In the present article Mr. Sayford describes this set-up in considerable detail and, in addition, refers briefly to some of the interesting surveying and mapping procedures that have been developed in the TVA work. His complete paper, of which this is an abridgment, was on the program of the Surveying and Mapping Division at the Society's 1939 Spring Meeting.

The survey and map requirements of the Tennessee Valley Authority, as anticipated in the summer of 1933, appeared considerably less complicated than they later proved to be. But as project followed project in rapid succession, it quickly became clear that the Authority was to face demands for surveying and mapping of such wide variety and great magnitude as was probably without precedent for one agency to accomplish in so short a time.

For each of the prospective reservoir projects, of which there came to be nine, there were required hundreds of acres of accurate large-scale site topography, together with numerous profiles; miles of layout surveys for probings, drillings, and test pits; preliminary location surveys for access routes; topography, location, and service layout surveys for construction towns; hydrographic and other exploration surveys for concrete aggregate; and so forth.

Dwarfing in magnitude the dam site surveys, however, was the volume of surveying and mapping pertaining to the reservoirs themselves—complete topography of the reservoir area; property surveys of thousands of tracts; the running out of hundreds of miles of prospective shore lines; large-scale topography and surveys of underground service structures in each of the several towns within or adjacent to the probable reservoir rim; and surveys to inventory and relocate the railroads, highways, cemeteries, and utility lines. Of course, as a basis for all these specific-purpose surveys, triangulation and traverses for horizontal control and accurate levels for vertical control were necessary throughout the valley.

Though only six years have passed since the start, the surveying and mapping program for the sixth successive reservoir project is now drawing to a close; for the seventh, Gilbertsville (as large as several of the others combined), the program is well started; for Watts Bar, the eighth, a beginning has been made; and for the ninth, preliminary work has been authorized. The total survey and mapping load for the nine specific reservoir projects is now thought to be about 2,500 man-years. About two-thirds that much work had been completed by June 30, 1939.

The dam and reservoir items constitute but one of the two major divisions of the Authority's surveying and mapping activities. Valley-wide standard base maps make up the other. From the beginning the Authority has been charged with many objectives other than the immediate construction of dams and reservoirs. Some call for valley-wide, long-range planning; some, also, for demonstration activities on select terrain; and the studies and plans required for them involve such fields as agriculture, forestry, minerals, industry, transportation, land use, town and regional planning, and electric power. It was early decided, therefore, that the Authority should ultimately have a complete set of topographic base maps of the Tennessee Valley, on a scale of 1 in. = 2,000 ft, with contour intervals of from 5 to 40 ft.

Mobile Plane-Table Unit in Operation

Note Bucks to Keep Truck Stationary. Light Is Admitted Through Flexible Glass Roof with Removable Cover

As it would be years before such maps could be prepared and published for the entire 40,000 sq miles, a compromise program was adopted providing for the immediate preparation of planimetric base maps on the scale of 1 in. = 2,000 ft, through the use of aerial photographs. It was intended that these should be made to exacting specifications to serve as base maps for topography. Contours were to be added later. A cooperative contract was arranged with the U. S. Geological Survey and the working program, planned and supervised by the Survey, resulted in completion of the planimetric maps in about $3^1/_2$ years, a rapid performance. As the planimetric maps neared completion, the preparation of topographic maps was begun in earnest and is still in process, although—due to reduction of annual mapping funds—at a much slower rate. This program is planned, directed, and financed by the Authority, in part on a cooperative working basis with the Geological Survey.

A necessary preliminary to the base maps and to the Authority's construction program was the completion in the Tennessee Valley region of the 25-mile spacing of first-order triangulation arcs of the U. S. Coast and Geodetic Survey, together with the first-order levels. At the Authority's request, the Coast and Geodetic Survey completed the work speedily, thus facilitating greatly the Authority's entire surveying and mapping program.

SWEEP BARGE WITH TOWBOAT, USED TO SURVEY NAVIGATION CHANNELS
Four Steel Rails Suspended from Cables Sweep the Bottom to Detect Navigation Hazards

Need for other base maps of certain areas beyond the Tennessee River watershed soon developed, notably for the extension of transmission lines and to furnish preliminary map information for regional planning studies. Some 20,000 sq miles have been completed, chiefly in cooperation with the State Geologist of Tennessee and the WPA. These maps, compiled by the automobile-traverse method, but using aerial photographs wherever available, show all roads, buildings, and other culture; drainage; and woodland areas.

SETTING UP THE SURVEYING ORGANIZATION

Formation of an organization to handle the Authority's surveying and mapping load was conditioned by several fundamental needs, the chief of which may be listed as follows (with no attempt to rank them in order of importance): (1) there was the need for capacity to handle the huge volume of work; (2) the need for speed; (3) the need for special skills to take care of many varieties of work; (4) the need for operating over a broad terrain; (5) the need for being ready to move forces and specialists quickly to meet overnight demands in new places; (6) the need for first-class work of appropriate accuracy and completeness in each category; (7) the need for a questioning attitude toward the status quo and for complete receptiveness toward new procedures and new ideas; and (8) the need for a high standard of citizenship and of public relations conduct. (This last ranks high in importance. The members of the surveying force were to make the first contacts with the people of the region, and the standards and purposes of the Authority would be judged by the impression they created.)

Obviously there was need for doing three things well—selecting the personnel; dividing the force into appropriate units; and effecting a high degree of decentralization and a large measure of individual responsibility.

As for personnel for immediate needs, in 1933, the Authority was in luck. The Army had just assembled near Norris (then called Cove Creek) Reservoir, some 300 civil service men of various professional and subprofessional grades, in readiness to carry on, should the Army be requested to construct the dam. The services of all or any of these men were tendered at once to the Authority, the Army arranging to place any surplus at other stations. Since no Authority personnel department was as yet available, a 5-man emergency personnel corps, consisting of men somewhat experienced in personnel classification or employment, was drumheaded into being. Forms and procedure were devised, and within less than a month each of the 300 had been thoroughly interviewed and reported upon, about 125 of them being selected, rated, and assigned.

A substantial proportion of these first recruits are still with the Authority and with few exceptions they have been promoted to higher grades. Later, the Maps and Surveys Division force was strengthened, reaching its peak of about 450 members in 1936. This figure excludes the force supervised by the Geological Survey on the compilation of planimetric maps.

Early in the course of operations it was determined to divide the field surveys force of the Maps and Surveys Division into parties, units, and area groups—3, 4, 5, or 6 men to a party according to type of work, 4 to 8 parties to a unit, and 3 to 5 units to the area group, depending upon the magnitude and geographical distribution of the work from time to time. Thus within an area group there might be included at one time any number of parties from 12 to 40; and within a unit, from 15 to 40-odd men, providing an organization mechanism of great numerical flexibility. For a while there were three area groups; these have now been consolidated into two.

The form of the field surveys organization is shaped chiefly for administrative convenience in handling efficiently a great number of small working units deployed over a broad region, and is strung on a vertical line of authority and responsibility leading upward from party chief to section head. The same organizational structure, so far as appropriate, was carried into other sections of the Maps and Surveys Division. In the Mapping and Drafting Section, for example, the "party" became the "squad," and the "field unit" the "functional office unit"—that is, the topographic unit or the checking unit, and so forth. In headquarter sections the area group, of course, is not necessary.

The Surveys Section, which is the largest numerically, will serve best to illustrate the organization pattern. Heading this section is the Chief of Surveys (George D. Whitmore, M. Am. Soc. C.E.), who has charge administratively and professionally of all the field work. His duties require the preparation of detailed instructions and specifications for each kind of survey, the teaching and demonstrating of procedures, and the direction and management of the field surveys force. To him report the two area engineers (one in charge of field work in the western half of the basin, the other in the eastern half), whose duties are principally administrative.

Reporting to the area engineers are the several unit chiefs, each stationed in a town more or less central to a region of heavy surveying demands. Each unit chief directly supervises, instructs, and inspects the field-survey parties assigned to his unit area. So far as practicable, the field parties composing a unit are required to live in the unit headquarters town, so that in addition to field visits, the unit chief may make morning and evening

contact with each. The close and intensive instruction, supervision, and inspection of a few field parties by the unit chief, which this set-up affords, is probably the basis for whatever success had been attained in the Authority's surveying work.

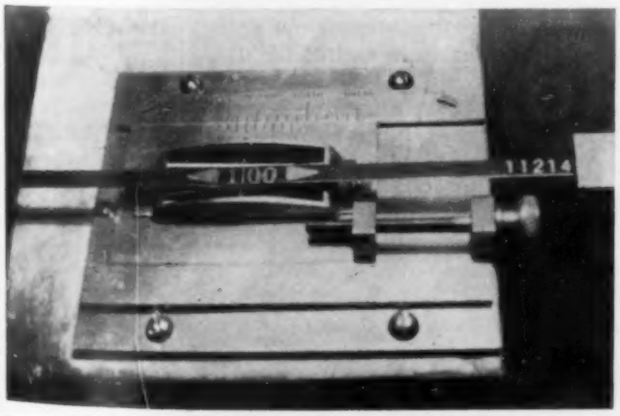
The unit chiefs were selected principally for combined abilities as supervisor, instructor, and inspector. Of course, each must also have a background of some years of general surveying work, but need not be a specialist in a particular branch. The party chiefs, on the other hand, were selected chiefly because of specialized training and ability in a particular branch of surveying. Certain party chiefs were employed, for example, because of years of experience in the production of large-scale plane-table topography. Others were selected for peculiar ability in recovering obliterated property corners; others because of ability to gain the confidence and aid of the mountain landowners.

The unit chiefs move seldom, every attempt being made to avoid moving a unit office until nearly all the various kinds of surveying work in the vicinity are completed. The parties and party chiefs, however, are prepared to transfer frequently and on short notice, thus providing great flexibility of talent and numbers combined with the stability afforded by the semi-permanent unit station and unit chief.

Young men coming into the organization as rodmen or recorders are selected, so far as possible, from graduate civil engineers standing high in their classes, who have indicated a preference for surveying and mapping work. An attempt is made to keep these young men interested and to afford them every opportunity to appraise the surveying and mapping branch of engineering as a career. Thus has been built up what is believed to be a unique and efficient surveying and mapping organization, which, decentralized to a high degree, can be depended upon for rapid, uniform, high-standard production.

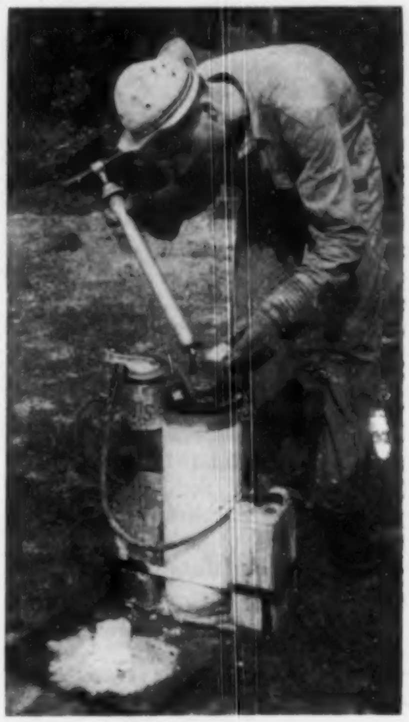
PLANNING AND DISSEMINATING TECHNICAL PROCEDURES

A vital factor in the success or failure of such an organization is the planning and dissemination of technical procedures. Such procedures for most types of surveys and maps with which we are concerned are worked out carefully by staff members, and after review are prepared in mimeograph form. The publication usually explains the primary purposes of the survey and its possible adaptation to surveys and maps which may be required later, includes specifications for accuracy and completeness, and finally furnishes detailed information reflecting experience on how the desired results may be obtained at lowest cost. Procedures are not allowed to become frozen or static, however. They are reviewed periodically, and the men are urged to offer suggestions for improving them.



End of 100-Ft Tape in TVA Calibration Device, Showing Method of Bringing Vernier-Piece Graduation Into Coincidence with Tape Graduation

Since most of the Authority's surveying and mapping is handled by one organization, there are many opportunities through careful planning to reduce or eliminate overlapping and duplication. Each proposed item of survey or map work is subjected to critical examination: first to make sure that the desired data are not already available from the results of previous work of the Authority or others; second, to see whether, with slight changes in procedure, a particular survey or map can be made to supply data which conceivably might be needed for other purposes. One or two examples will suffice to illustrate these planning policies.



Paint-Spray Gun Developed by TVA Survey Forces for Semi-Permanent Contour Marking on Trees, Buildings, Rocks, and Pavements

Cylinder Is Being Loaded with Dry Ice, Vaporization of Which Creates the Necessary Pressure

Among the reservoir surveys, the control traverses and levels are executed first. Their routes and station locations are planned so as not to be obliterated later by rising pool water, road relocations, and so forth. Substantial concrete monuments with embedded bronze tablets, in intervisible pairs where possible, are set along the routes at intervals averaging about one mile. These are used for both traverse stations and bench marks. The results—monument locations, station positions, elevations, and references, together with index maps—are then published in lithographed pamphlet form. Included in each pamphlet, also, are the results of all standard control surveys which have been executed in the vicinity by other agencies.

Two simple requirements of control procedure, found to be especially effective in eliminating overlapping efforts, are (1) that all vertical surveys shall be executed on the official mean sea level datum, and (2) that the results of all horizontal surveys shall be computed, and the maps plotted, on the appropriate state-wide plane coordinate system. Thus the vertical and horizontal relations of all project points are available at any moment.

AERIAL PHOTOGRAPHY EMPLOYED FOR LAND ACQUISITION SURVEYS AND TOPOGRAPHIC MAPS

It is not possible here to refer other than briefly to specific surveying and mapping procedures. Perhaps the land acquisition and the small-scale topographic mapping procedures are of most interest because of the extensive use in them of aerial photography.

Procedures for land acquisition surveys and plats are governed by the fact that numerous individual tracts are being acquired and merged into one large reservation. There is no need for preserving boundaries of small interior tracts; hence methods less costly than those involving the usual transit-tape or transit-stadia boundary surveys may be utilized. This fact was instrumental in the decision to try the use of aerial photographs in property surveying.

The paucity of property maps everywhere in the Tennessee Valley made it necessary that in each reservoir region reconnaissance maps, showing ownerships and approximate property lines, be constructed. The manner of doing this involves the use of aerial photographs and is believed to be unique, but must be omitted here.

Detailed property surveys are confined to selected areas delimited from the property reconnaissance maps. Aerial photographs, scale-checked and accurately ratioed up to an apparent scale of 500 ft to the inch, form (together with traverse control) the basis for most of the farm surveys. Acreages are planimetered and tract-boundary descriptions scaled directly from the resulting land plats, which are rectified in the office for photographic relief displacement and plotted to a scale of 500 ft per inch.

FOUR-LENS AERIAL CAMERA, MOUNTED IN PLANE, FOR STEREO-PHOTOTOPOGRAPHIC WORK

ACCURACY OF AERIAL PROPERTY SURVEYS

The results of more than a hundred experimental tracts so surveyed have been compared with results obtained for the same tracts by the usual ground methods. From all these tests it appears that the average error in the planimetered tract acreage is less than 1 per cent. Plus and minus errors are well balanced. The maximum difference, reported more than three years ago, about 4 per cent, still remains the record. The error of scaled boundary courses averages 10 to 15 ft, and downright blunders are less frequent with photographic methods. Thus results are well within reasonable tolerances and are accepted without question by the property owners.

These maps are made to record inexpensively a wealth of interior property detail, essential for the appraisers to examine, but which could not have been included without the use of aerial photographs, except at enormous additional expense. Appraisals are thus improved and cheapened, and duplication of effort is minimized.

White-paper plane-table stadia surveys on a larger scale are used for very small farms, and steel-tape surveys for city and town lots.

The land surveys and maps are made to include also the accurate locations of several contours around the rim of each reservoir for use in land-purchase control, reservoir-clearance delimitation, navigation charting, borderland-use planning, property management, and for numerous other purposes, exemplifying again the saving in money and effort to be derived from a unified outlook and careful advance planning on a multipurpose project.

The valley-wide topographic maps are constructed on a 2,000 ft to the inch scale by two principal processes. The procedure most employed to date involves the processing of aerial photographs by stereoscopic plotting instruments, a method now known to be splendidly adapted to the production of topographic maps of hilly and mountainous country. The second, used only in relatively flat terrain, employs the orthodox plane-table method varied somewhat by the use of machine-plotted planimetric maps as plane-table sheets, or, where the terrain is devoid of excessive relief, of accurately ratioed aerial photographs.

More than half the machine-plotting has been executed by Geological Survey topographers, trained as operators on the job, using Multiplex Aero-Projector instruments manufactured by the Zeiss Company (see "The Multiplex Stretches the Survey Dollar" by T. P. Pendleton, M. Am. Soc. C.E., in CIVIL ENGINEERING for July 1939). Most of the remainder of the stereoscopic plotting has been done by a commercial aerial mapping firm under contract, using the Stereoplanigraph instrument, also manufactured by Zeiss.

So far neither organization has attempted to draw maps of terrain of such low relief that a contour interval of less than 20 ft is appropriate, although in occasional fairly flat areas, occurring amidst steep terrain, and at critical points such as saddles, passes, hill tops, and deltas, 10-ft half-interval contours have been drawn quite successfully.

STEREOSCOPIC WORK IN FLAT TERRAIN

A third type of stereoscopic plotting equipment—the Brock and Weymouth, of American make—is now, however, being tried in low relief country. The contract (not yet completed) calls for 10-ft contours, with occasional 5-ft half-interval contours. If the maps are accurate and point to a cost comparable with that of ground surveys, plane-table procedure for extensive small- or medium-scale topographic mapping, even of the flatter terrain, may soon be outmoded.

To measure the savings accruing from any of our aerial mapping work is difficult—largely because the photographic methods furnish, at relatively small added expense, much valuable information not afforded by ground surveys except at prohibitive costs. The full sums saved to the Authority in land acquisition work alone, for example, can never be known. But if only 10 cents per acre were to be saved in the direct cost, the total would come to $200,000. The actual direct savings on simple cadastral surveys and maps are believed to be several times 10 cents per acre, and the direct overall costs of equivalent comprehensive results are much less than half the costs of ground methods. And it is quite conceivable that the multiple uses of the basic maps derived from the aerial pictures account for savings in eliminating separate surveys, and in planning work and execution, amounting to many other hundreds of thousands of dollars.

Subway Station Layouts

Wide Variety in Facilities Raises Question of Possible Standardization in Future Work

By H. George Altvater

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SEVENTY-FIVE different arrangements of tracks, platforms, and columns have been noted by Mr. Altvater in a personal inspection of subway stations in four American cities. Such a variety of designs, he suggests, is not conducive to the best handling of passenger transportation. True, the design of underground structures is influenced more by limitations of construction than by the requirements of use; nevertheless, some standardization would appear to be possible and desirable in future work. The author presents his data with a view to stimulating discussion on this point.

A RAPID transit line is an artery for the speedy conveyance of passengers within a metropolitan area without obstruction due to cross traffic. Obviously it may be elevated above the street surface, or depressed below it, and if located below the surface it may be either open or covered. Strictly speaking, we should include express highways under the term rapid transit, but as common carriers have not found it practicable to operate on them to date they are not considered here. This article deals mainly with the arrangement of tracks, platforms, and columns in covered subway stations of rapid transit rail lines.

The difficulties in dealing with the requirements of private property adjacent to stations have produced an ever-increasing variety of station arrangements. Although there may be little additional cost in constructing each station on a different plan—so long as the construction details are similar—the matter of walking distances of passengers and simplicity of passenger pedestrian routes seems to have been accorded little importance. To oblige passengers to explore a new and intricate labyrinth of passageways at each station, and to crane their necks in all directions in order to orient themselves on reaching the street surface, is not conducive to the best handling of passenger transportation.

With a view to bringing about a better consensus of opinion regarding the most desirable types of station arrangement, and the possibilities of standardization, there is presented here an approximate summary of existing station cross-sections in four American cities where subways were operated in 1938. (See Table I and Fig. 1.) These data were obtained by personal inspection, and doubtless a careful examination of the actual plans would result in slight revisions. However, such changes should not affect the general conclusions. A number of stations have different cross-sections in different portions, and some are so irregular that their different parts are listed separately.

A Local Station of the Independent System, New York
Type 2-2S-4, Permitting Future Addition of Third Track

The nomenclature, which is original, gives the total number of tracks as the first symbol, the total number of island and side platforms as the second symbol, and the total number of intermediate columns or walls as the third symbol. Thus, type "4-2I2S-3" indicates a total of 4 tracks at approximately the same level, with 2 island platforms and 2 side platforms, and 3 intermediate columns not counting the wall columns at the outside. Where the longitudinal spaces between columns are filled with walls to promote the piston action of the ventilation, or where walls are used in place of columns, these are indicated as columns. The following nomenclature is used:

DH—double head	I—island platform
DD—double deck	S—side platform
TD—triple deck	L—lowest elevation
TER—terraced tracks	M—middle elevation
X—subway crossing transfer station	U—upper elevation

It must be remembered that although they are not shown in the sketches, mezzanines or passageways are required by the island platforms, either above or below the subway tracks and train clearance limits, for access from the street surface. Mezzanines are generally above the track level, although the stations at 34th Street, both at Seventh and at Eighth Avenue, New York, have underpasses of considerable area because the clearances for the Pennsylvania Railroad structures underneath make it impossible to lower the grade of the subway to permit a mezzanine above. In Philadelphia the passageways above the tracks merge into mezzanines, as is also the case in the 14th Street station of the New York I.R.T., but generally the word "passageways" is used here to refer to passages below the tracks. The platforms at Boston, Newark, and Philadelphia are in some cases low although shown as high in the diagrams.

Besides variations in methods of operation, in handling of passengers, and in types of rolling stock and other equipment, there is a basic difference between the London Underground and the New York subways (also the subways in Newark, Philadelphia, Berlin, Moscow, Buenos Aires, and Tokyo) as regards method of construction, which affects design and cost. In London, the lines are so far below the surface that the material between the structure and the surface is not removed, the tunnels being excavated by drifting horizontally. This permits the construction of mezzanines without any change in

elevation in top of rail. (Mezzanines are necessary there because of the use of paper tickets for fare collection. With the manual change booths and the nickel-in-the-slot automatic passimeters used in New York, very little space is required in addition to the train platforms.)

In New York there are a small number of deep tunnels, but by far the major portion of the mileage has been built by the cut-and-cover method. This means that the full excavation is made from the surface, the walls built, and the subway roof covered with earth to carry the street surface. (There is over 3 ft of backfill between the top of the subway structure and the bottom of the pavement, to provide space for water, gas, electricity, and other utilities; 6 ft is the minimum from subway ceiling to crown of street paving.) Literally, however, the work cannot be done in this sequence because of the necessity for maintaining street traffic. Hence the sidewalk and paving are removed in areas about 30 ft square, and sufficient material is excavated to permit the placing of steel carrying beams and wooden decking for temporary traffic. The street is fairly well covered in this manner for a considerable length, and temporary gas mains are installed at the curb lines. Then the remainder of the excavation is made by steam shovels working underneath the wooden decking, or by other means, from major points of construction access. Underpinning of adjacent buildings, construction of the subway structure itself, and installation of utilities, all progress in such portions and at such locations as required or permitted by the excavation. After the subway structure and utilities are completed, the street is backfilled, and the paving and sidewalks are replaced.

In considering station types, at the start we are confronted with the fact that the predominant 4-track local

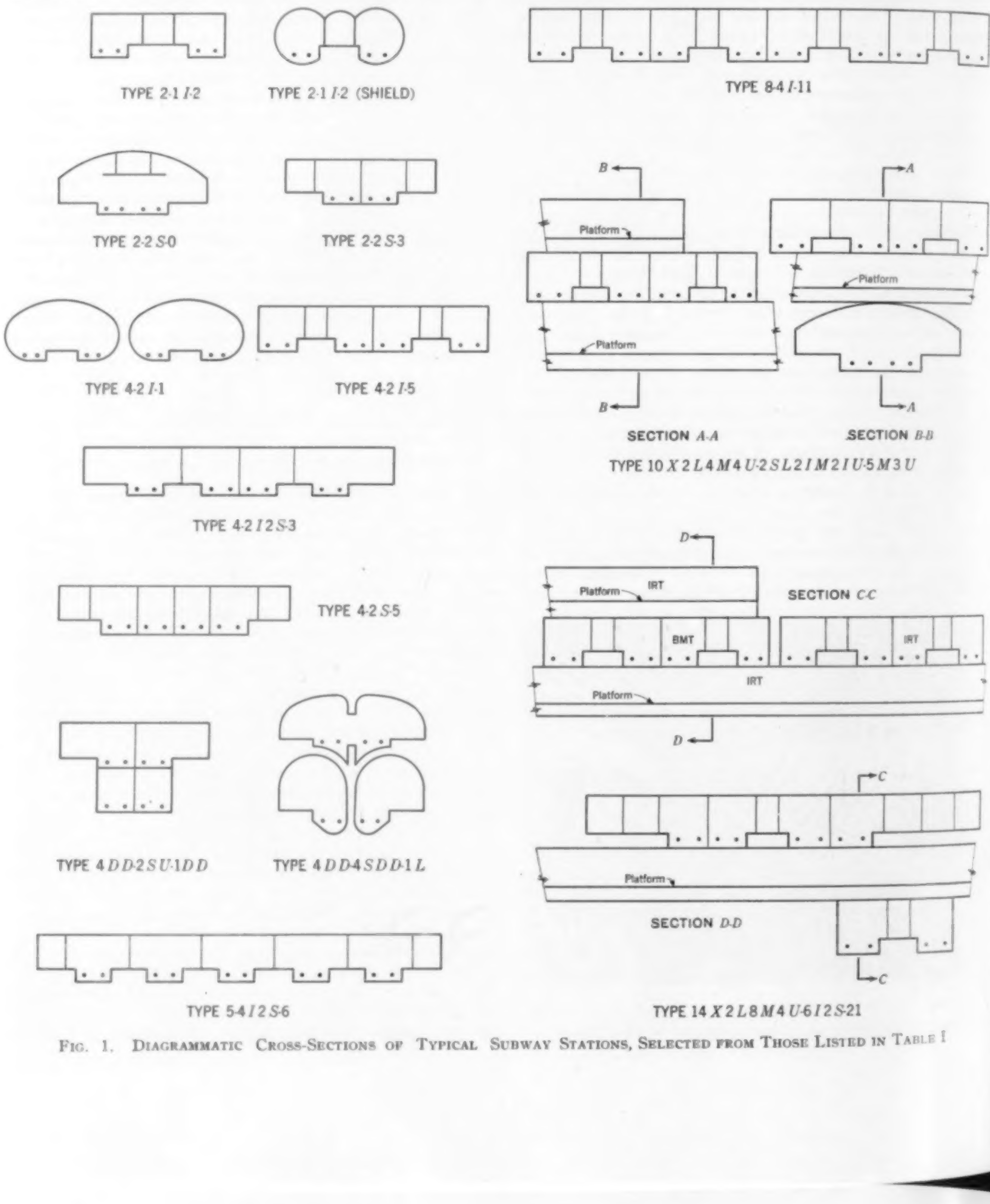

FIG. 1. DIAGRAMMATIC CROSS-SECTIONS OF TYPICAL SUBWAY STATIONS, SELECTED FROM THOSE LISTED IN TABLE I

type (4-2S-3 or its alternate, 4-2S-5) has advantages which do not permit the substitution of any other type for it. By means of a sub-passageway below the tracks, as at the 110th Street station of the New York I.S. (Independent System), no passengers are required to cross the street at the surface; minimum distance from surface to top of rail is permitted; side platforms offer easy access to basements and first floors of retail establishments, and also permit display windows fronting on subway platforms; and no spreading of tracks is required for platforms. Where streets are narrow it can be replaced by type 4DD-2SU-1DD, which can be built in solid rock at little extra cost. Both these stations require opening of the right-hand doors of cars of local trains, so that for 2-track lines, the predominant 2-2S-3, or its newer modification 2-2S-1, should be used to accompany them.

Practically all express trains become local trains before they reach the end of their run, and it is advantageous to have them always open doors on the same side. The 2-2S-3 type accompanied by the 4-2I-5 type requires no change in the door opening of express trains. Although perhaps many readers, as well as the writer, have seen cases where trainmen opened the doors on the wrong side of the train, making it possible for passengers to be pushed off or to step out where there is no platform, such occurrences are of course not publicized, and data are not available. Where the shining white tile walls of type 4-2I-5 stations are within a foot of the car doors there is of course less danger from doors opened on the wrong side than on an elevated structure, where it might be possible for a passenger to fall to the street surface. In designing stations, the aim of securing the best door opening must be weighed against other factors. In the case of express stations, this factor must be balanced against the advantages of cross-platform transferring between express and local trains. It is obvious that if cross-platform transferring is used, some trains must open the left-hand doors and other trains must open the right-hand doors. As trains that are expresses in downtown districts become locals in residence districts, there must be a change from right-hand to left-hand door opening at some point in the operation of some trains, either locals or expresses.

TABLE I. APPROXIMATE SUMMARY OF SUBWAY STATIONS IN BOSTON, NEW YORK, NEWARK,† AND PHILADELPHIA

Type	Boston	New York B.M.T.	New York I.S.	New York I.R.T.	Hudson Tubes	Philadelphia	Other Examples in
1-1S-0	..	1	..	..	..	..	.....
2-1I-0	..	..	..	..	..	..	Berlin
2-1I-1	..	1	1	2	..	..	.....
*2-1I-2	4	8	7	4	2	3	Chicago, Berlin, Moscow, Tokyo
*2-1I-2 (Shield)	..	..	2	1	2	..	London, Moscow
2-1I1S-3	1	..	..	..	..	..	.....
2-1I1S-4	..	..	2	..	..	..	.....
2-1I2S-0	1	..	..	..	..	..	Barcelona
2-1I2S-2	..	..	..	..	..	..	Athens, Barcelona
*2-2S-0	1	..	..	2	..	1	London, Paris
2-2S-1	2	4	2	..	..	3	Buenos Aires
2-2S-2	2	..	..	..	..	..	.....
*2-2S-3	10	16	16	12	4	3	Moscow, Tokyo
2-2S-5	..	..	1	..	..	3	.....
2DD-2SDD-0	..	1	1	..	..	..	.....
2DD-2SDD-1L	..	..	1	..	..	..	.....
2DD-2SDD-2DD	..	..	..	1	..	..	.....
2DD-1SL1SU-1L1U	..	1	..	..	..	..	.....
2DD-1SL1SU-1L2U	1	..	..	..	..	..	.....
2DH-2S-0	..	..	.	..	1	1	London
2TER-2S-3	1	..	..	..	..	..	.....
3-2I-2	..	1	1	..	..	..	.....
3-2I-4	..	..	4	..	..	..	.....
3-2I-5	..	..	1	..	..	..	.....
3-2I1S-5	..	..	..	..	1	..	.....
3-2I2S-6	..	..	..	..	1	..	.....
3-2S-2	..	..	..	1	..	..	.....
3-2S-4	..	..	8	7	..	..	.....
3-1I1S-3	..	..	..	2	..	..	.....
3-1I1S-4	..	..	1	..	..	..	.....
3-1I1S-5	..	1	..	..	..	..	.....
3X1L1M1U-3S-7	1	..	..	..	..	..	.....
4-1I2S-4	..	..	5	..	..	..	.....
4-1I2S-6	..	..	..	2	..	..	.....
*4-2I-1	..	..	..	..	..	..	Paris
4-2I-3	3	1	5	1	..	..	Chicago
4-2I-4	..	3	4	4	..	1	.....
*4-2I-5	1	2	4	1	..	8	.....
*4-2I2S-3	..	..	..	1	..	..	.....
4-2I2S-4	..	..	..	..	..	1	.....
4-2S-2	..	2	..	..	..	..	.....
†4-2S-3	..	..	8	..	..	9	.....
4-2S-4	..	..	..	..	..	2	.....
*4-2S-5	..	7	13	24	..	..	.....
4-3I-6	..	..	1	..	..	..	.....
4-3I2S-7	..	1	..	..	..	..	.....
4DD-2IDD-4DD	..	1	4	5	..	..	.....
4DD-2SDD-4DD	..	..	4	1	..	..	.....
*4DD-2SU-1DD	..	..	..	5	..	..	.....
*4DD-4SDD-1L	..	..	..	..	..	..	Paris
4DD-4SDD-2DD	..	..	..	3	..	..	.....
4DD1L3U-4S-1L4U	..	..	..	1	..	..	.....
4DD2L1M1U-1SL1SU-3L1U	..	..	1	..	..	..	.....
4TER-4SDD-3U	..	..	1	..	..	..	.....
4TER-2S-5	..	..	1	1	..	..	.....
4X2L2U-1IL2SU-2L1U	..	..	..	..	..	1	.....
4X2L2U-2I-4	1	..	..	..	..	..	.....
5-2S-3	..	2	..	..	..	..	.....
5-2S-4	..	2	..	..	..	..	.....
5-3I1S-8	..	..	1	..	..	..	.....
*5-4I2S-6	..	..	..	..	1	..	.....
5X2L3U-2SL2IU-4U	..	..	..	1	..	..	.....
6-2I-6	1	..	..	..	..	..	.....
6-2I-7	..	1	..	..	..	..	.....
6-2S-7	..	..	1	..	..	..	.....
6-3I-6	..	..	1	..	..	..	.....
6DD2L4U-2SL2SU-4L5U	..	..	1	..	..	..	.....
6X2L4U-1IL2IU-2L3U	..	1	..	1	..	..	.....
6X2L4U-1L2IU-2L4U	..	3	1	1	..	..	.....
6X2L4U-1I2S12I-1SU-2L6U	1	..	..	..	..	..	.....
7DD3L4U-2IL2IU-10DD	..	..	1	..	..	..	.....
7X2L1M4U-1IL1SM2IU-2L5U	..	..	1	1	..	..	.....
*8-4I-11	..	..	1	..	..	..	.....
*10X2L4M4U-2SL2IM2IU-5M3U	..	..	..	1	..	..	.....
*14X2L8M4U-6I2S-21	..	1	..	1	..	..	.....

* Shown schematically in Fig. 1. † Newark's three stations are all of the 4-2S-3 type.

The only alternative would be to have a platform on the proper side of each single track, which would not permit cross-platform transferring. Such stations are used at the terminals of the New York Hudson Tubes, where standing passengers are handled more efficiently, probably, than anywhere else in the world, because egress from trains is permitted on one side while the passengers are entering on the other. In Paris, at loop terminals, trains unload passengers onto platforms at both sides of the inbound track and take on others from both sides of the outbound track. Except for these two cases and some in Boston, the subways have not provided platforms on both sides of each track, particularly at way-line stations. However, with the more intensive use of present subways in the future, this feature may have to be incorporated.

Observation of the traffic at the 4-2I-5 stations in Manhattan—particularly at 42d Street, 96th Street, and 14th Street—shows the advantages of this type. The greater capacity of the platforms and the passageways, the ease and convenience of transferring between express and local trains, and the much shorter time consumed by each passenger in the station, lead definitely to the conclusion that the platforms at express stations should be placed between the express tracks and the local tracks.

EXPRESS STATION (TYPE 4-2I-5) IN PHILADELPHIA
Four Tracks, Two Island Platforms

Type 4-2I-5 stations require opening of the right-hand doors of express trains, which fits in nicely with the right-hand opening on such trains at the 2-2S-3 type of local stations beyond the express territory. Of course, the use of 4-2I-5 express stations with 2-2S-3 local stations requires local trains to open the right-hand doors for local stations and the left-hand doors for express stations; but these form a logical combination with 4-2S-5 and this seems to be preferable to alternating right-hand and left-hand openings on express trains.

In the writer's opinion, a type 4-2I2S-5 station (like that at 96th Street and Broadway in New York), if supplied with escalators, might be found preferable to the 4-2I-5 type. At any rate the three types, 4-2I-5, 4-2S-5, and 2-2S-3, may be considered the present approved combination of stations for a subway line.

A simpler but more costly combination, with mezzanines at all local stations, would be the 4-2I-4 and 2-1I-1 types. In New York, because of difficulty in filling up local trains on the 7th Avenue I.R.T. line, the new I.S. system has eliminated many local stops. The latter was purposely planned so that all trains would stop at practically all stations in the business district—from 59th Street Manhattan, to Borough Hall, Brooklyn. This arrangement minimizes interchange of passengers and develops substantially the full four-track capacity. Additional experience may prove the superiority of this method of operation, wherein the express territory starts at the edge of the main business section.

ADVANTAGES OF MEZZANINES

Mezzanine floors make it unnecessary for passengers to cross the street at the surface and permit a 50 per cent reduction in change-booth employees at stations with side platforms and no sub-passageways. The New York I.S. found that it cost almost the same to provide permanent open mezzanine space not used as it did to backfill and provide only passageways as in Philadelphia. It would appear that it is not economically justifiable to lower the grade of the subway track by more than 3 or 4 ft to provide mezzanines, but they should be built where space permits. The United States designers of the Buenos Aires subway seem to have arrived at this conclusion.

It should be added that mezzanines permit narrower platforms because the longitudinal paths of passengers are not on the platforms themselves.

Three-track rapid transit lines have not proved entirely practicable, because the public seems unable to memorize the time schedule for trains going in each direction on the center track, and because all return traffic must be run on one track. Staggered platforms are also confusing.

While it is not my intention here to discuss dimensions in detail, a few general remarks may be in order on such matters as height and clearance of platforms. Generally, high platforms are the same level as car floors, but as cars of different transit systems and different manufacturers vary, there is no uniformity. At Flatbush, in Brooklyn, where the tracks were raised without raising the platforms, it was observed that passengers had no difficulty in stepping up into the cars, but the railroads have found that where car floors are lower than platforms some of the taller passengers bump their heads on the tops of the car door frames, and damage suits result. Some of the recently built elevated platforms of the Hudson Tubes have been made some 7 in. lower than the car floors at the writer's suggestion. This gives the car designer some latitude so that he may lower the floor if he wishes, and permits a variable step of 6 to 11 in. to take care of lack of uniformity in car-floor heights. A step of less than 4 in., however, constitutes a hazard.

The side clearances of car platforms, which become very troublesome at sharp curves and near crossovers or switches, should be kept to a minimum so that passengers will not step into the hole between the car and the platform, and yet must not be less than the allowable minimum of 3 or 4 in., so that rapidly moving trains with swaying cars will not tear the platform to pieces. Curves with a radius of more than 1,500 ft are not objectionable from the passenger standpoint, but the trainmen cannot see the full length of trains on the convex side. On railroads the small side clearances of high platforms result in speed restrictions on trains. This may be alleviated somewhat by having the platforms 6 to 11 in. lower than the car floors. Having the platform lower than the car floor also calls for less mental effort on the part of passengers, for even in a closely packed crowd they are made aware that the platform edge is just ahead of them by seeing others step up.

Another factor that should be taken into consideration in any standardization of station layouts is that in every American city that possesses both elevated lines and subways, the same trains operate on both. The plan of elevated stations should therefore conform to that of subway stations on the same line.

Transportation history has shown that long before a subway can be financed in a city of less than 3,000,000 population, it becomes feasible to finance an elevated structure. Many cities having between 500,000 and 3,000,000 population cannot finance a sufficient mileage of subway to provide effective rapid transit service. On the other hand, a 25-year elevated system could be financed, and would produce much greater real estate development by the end of twenty years than the present procedure of allowing surface facilities to struggle with the problem in the interval. The elevated structures are the "builder-uppers" of real estate assessed valuations, which really provide the taxes to pay for a subway.

Most existing elevated structures were built before the advent of automobile traffic. New elevated high-speed lines must overcome the objections of (1) unsightly appearance of station facilities, (2) objectionable noise, (3) the use of an even number of rows of columns whereby the street is divided into an odd number of sections, and (4) unnecessary obstruction of light needed by stores fronting on the street. Replacement of every elevated structure must be contemplated when and if street traffic and property values reach an intensity that will justify the initial construction cost of a subway.

Aluminum Alloys for Engineering Structures

A Discussion of the Properties and Principal Applications of Alloys 27S-T and 53S-T

From a Paper Presented at the 1939 Spring Meeting of the Society

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Heat-treated aluminum alloys were first produced in this country during the early years of the World War to fill the need for a high-strength, light-weight structural material for aircraft. At present four alloys of this class are most commonly used and are available in a variety of structural forms. One of these alloys, designated as 24S-T, is peculiarly adapted to the requirements of aircraft, and its use is largely in that field. A second alloy (17S-T) has been ably discussed by E. C. Hartmann, Assoc. M. Am. Soc. C.E., in his paper, "Structural Application of Aluminum Alloys" (Transactions, Am. Soc. C.E., Vol. 102). During recent years two other strong aluminum alloys have gained importance because of special qualities that render them useful for specific applications. These alloys are designated as 27S-T and 53S-T. The first is notable for its combination of unusually high strength with the light weight common to all aluminum alloys. The second has proved remarkably resistant to many corrosive agents.

In common with other aluminum alloys, the total quantity of alloying elements is relatively small. Alloy 27S-T carries approximately 4.5 per cent copper, 0.8 per cent silicon, and 0.8 per cent manganese. Thus nearly 94 per cent is aluminum with a very small amount of other elements and impurities. Alloy 53S-T consists of approximately 0.7 per cent silicon, 1.3 per cent magnesium, 0.25 per cent chromium, over 97 per cent aluminum, and a small percentage of normal impurities.

Aluminum alloys are used structurally because of their light weight or their resistance to corrosion. All the alloys possess two qualities in common: they weigh in the neighborhood of 170 lb per cu ft and their modulus of elasticity is about 10,300,000 lb per sq in. Yield strength and ultimate strength vary with the alloy. There is also some difference in resistance to corrosion which may, in certain cases, determine the choice of material.

Typical mechanical properties of the two alloys under discussion are given in Table I. The mechanical properties of one represent the upper range of strength for commercially available aluminum alloys. The mechanical properties of the other are somewhat lower, but have proved adequate for many structural applications.

In the case of both these alloys, there is an adequate background of laboratory and field experience to forecast their behavior under various types of exposure. In either industrial or seacoast atmospheres only superficial attack of exposed surfaces of Alloy 27S-T may be expected. The surface layer of oxide tends to protect the underlying metal and the rate of attack definitely decreases with the passing of time. In other words, corrosion tends to be self-stopping. One sample shows the characteristic dark surface found in a smoke-laden atmosphere, the other the whitish surface characteristic of seacoast exposure. On the other hand, this alloy is not recommended for use where there is constant exposure under water, because the corrosion product formed in such cases is of a gelatinous texture offering no protection to the underlying metal. For structures built of Alloy 27S-T, priming with an inhibiting type of paint is advisable.

Alloy 53S-T is outstanding in its stability. The durability of store fronts and window frames in cities throughout the country is visual evidence of its resistance to corrosion by industrial atmospheres. Its successful use in naval vessels illustrates its stability in marine environments.

The paper by Mr. Hartmann, previously mentioned, describes the fabrication of 17S-T. Mr. Hartmann's remarks are generally applicable to 27S-T and 53S-T with one important exception. In forming 17S-T, reheat-treating may be avoided if the metal is heated to not more than 400 F. However, even heating to this temperature impairs its subsequent resistance to corrosion. Alloys 27S-T and 53S-T may be heated to 400 F without affecting their mechanical properties or subsequent resistance to corrosion.

Jointing of Aluminum Alloy Structures

The jointing of aluminum alloy structures requires some discussion. In situations where extreme weight saving or uniformity of appearance is important, aluminum alloy rivets can be used. They are driven either hot or cold, depending on the size and alloy. Shear strengths of 34,000 lb per sq in. can be obtained by using hot-driven aluminum alloy rivets, but rigid control of temperatures and driving procedure is essential.

The majority of aluminum alloy structures have been fabricated with hot-driven steel rivets, using standard equipment and procedure. Alloy 27S-T is particularly well adapted to this practice, since its strength and resistance to corrosion are not adversely affected by the heat as long as the usual procedure of staggering the riveting operation is followed.

Cold driving of steel rivets is done successfully. It is believed worth while to detail the experience of one job, on which about 6,500 $^{3}/_{4}$-in. diameter and about 20,000 $^{7}/_{8}$-in. diameter steel rivets were driven. Best results were obtained when the diameter of the rivet hole was $^{1}/_{32}$ of an inch larger than the nominal diameter of the rivet. (In a larger hole than this, the rivet has a tendency to cock sidewise as it is driven.) A squeeze riveter of 80 tons capacity, with air pressure at 100

Table I. Typical Properties of Alloys 27S-T and 53S-T

Property	Alloy 27S-T	Alloy 53S-T
Tension		
Yield strength,* lb per sq in.	50,000	33,000
Ultimate strength, lb per sq in.	65,000	39,000
Shear		
Yield strength,* lb per sq in.	30,000	20,000
Ultimate strength, lb per sq in.	39,000	24,000
Endurance limit,† lb per sq in.	13,000	11,000
Elongation, per cent in 2 in.	11	20
Brinell hardness (500-kg 10-mm ball)	115	80
Weight, lb per cu ft.	174	168

* Yield strength is the stress which produces a permanent set of 0.2 per cent of the initial gage length.

† Endurance limits are based on withstanding 500,000,000 cycles of completely reversed stress, using the R. R. Moore type of machine and specimen.

lb per sq in., was used. A reducing valve was placed in the air line, supplying air at 65-lb pressure when driving $^3/_4$-in. rivets, and at 95-lb pressure when driving $^7/_8$-in. rivets. The total pressures were thus 52 tons or 76 tons.

When pressure is applied, the rivet shank first fills the hole, then the rivet end upsets to form the head. When the driven head fills the set, travel of the set stops, the stroke of the riveter being so adjusted. There should be $^1/_{16}$ to $^1/_8$-in. clearance between the face of the set and the metal surface adjacent to the rivet head.

Cold-driven rivets are uniform. Pressure and travel of set can be adjusted to be exactly right and exactly the same for all rivets in a given run. Cold driving is about 75 per cent as fast as hot driving, as the characteristic motion of the squeeze riveter is slower. The driven heads for this job were not button-shaped, but resembled short cylinders surmounted by a flat cone. All rivets were annealed before being driven.

Welding is used in certain cases, but is limited in its usefulness by the fact that the carefully controlled structure of the heat-treated alloys is adversely affected by the heat of welding, and the strength of the metal at, and adjacent to, the weld is reduced. In some cases parts can be reheat-treated after welding, but in general welding is restricted to minor non-stressed members.

A discussion of the design of aluminum alloy structures is beyond the scope of this paper. The fundamentals are similar to those for any other structural material, but the differences in mechanical properties must be given adequate consideration. As a result, a properly designed aluminum structure differs in detail and in proportions from a similar structure of other metals. This aspect of design has been given careful consideration in numerous technical papers, in a handbook on aluminum alloy structures, and in detailed specifications which have been or are being prepared.

EXAMPLES OF STRUCTURAL APPLICATIONS

Final acceptance of any material as a useful structural commodity must be based on actual experience under normal working conditions. The applications which follow are chosen to give some idea of the diverse fields in which alloys 53S-T and 27S-T are being, and have been, service tested. The first series of illustrations concerns Alloy 53S-T, a material which combines good mechanical properties with a resistance to corrosion substantially equal to that of commercially pure aluminum.

One of the large applications of Alloy 53S-T has been for decorative trim on buildings and for such items of building hardware as doors and windows. It is of particular value for use in sewage disposal plants, where minute quantities of hydrogen sulfide in the humid air cause rapid corrosion of most other structural metals. Alloy 53S-T is immune to this type of attack, and is accordingly used quite often for such items as sash, skylights, doors, hand-rails, and gratings. Skimming weirs, trash racks, and sluice gates have also been built of it.

In public utility work, considerable care is taken to avoid interruptions. The use of a corrosion-resisting material for structures supporting conductors removes the necessity of painting. Also aluminum, being a nonmagnetic material, may be placed closer to large conductors, such as generator leads, than other metals. In one large steam power station in the Pittsburgh area, 53S-T is used to form a bridge carrying generator leads. This bridge consists of two 30-in. plate girders, 37 ft long. A large number of aluminum brackets have also been used for supporting other conductors at this plant.

Alloy 53S-T has been used extensively in naval vessels. In order to establish its fitness for this purpose, a section of the hull of a vessel was fabricated in a well known shipyard, using the regular shipyard force and without recourse to special tools or processes. The framing of this hull was composed of 53S-T shapes and extrusions, and numerous severe forming operations were involved. Many of these operations were carried out cold, while the more difficult were accomplished at 400 F. Rivets are 53S-W, cold driven.

This test hull was equipped with typical fittings, including one bronze and one stainless steel propeller, to simulate actual conditions of corrosion where dissimilar metals are involved. It has been moored in relatively warm waters at Newport News, Va., since December 16, 1935, except for brief periods when it has been removed for inspection, and has had paint maintenance typical of that employed for naval vessels. The last inspection was in March 1939, at which time the metal was found to be in good condition, with no appreciable corrosion attack which would indicate a reduction in strength.

Alloy 53S-T has been used fairly extensively in the manufacture of exterior hand-railing, usually on bridges. Since painting is not necessary, considerable maintenance expense is avoided. Light rolled or extruded sections, and light tubing, are usually used in these applications. Balusters or railing spindles may have a wall thickness of $^1/_{16}$ in., and rails perhaps $^1/_8$ in. These thicknesses have proved entirely adequate in practice.

Turning now from 53S, which is used where the considerations of maximum resistance to corrosion and a minimum of maintenance overcome the consideration of maximum strength, we shall consider practical applications of Alloy 27S-T, which combines good resistance to ordinary exposure with high strength.

One of the outstanding uses of Alloy 27S-T is in the construction of heavy-duty mining equipment where strength, hardness, and corrosion resistance are essential. Cars used to transport iron ore from shaft head to stock piles are of particular interest. Use of aluminum alloys in these cars has permitted an increase of 50 per cent in the load carried without increasing the gross live load on old stocking trestles. As another example, in one copper mine a triple-deck aluminum mine cage, carrying 36 men, has replaced a double-deck, 24-man cage, thus effecting a saving of 13 min. per shift in transporting miners.

In one installation on the Great Lakes, a coal bucket with a capacity of $12^1/_2$ tons includes 27S-T plates to reduce dead weight and to withstand the shocks and abrasion incidental to unloading coal vessels. This single bucket and bridge does the work of two heavyweight buckets and bridges of 7-ton capacity which it replaced. Many of the trolley parts are of aluminum alloys to effect further weight reductions.

The Corps of Engineers, U. S. Army, has used structural aluminum for emergency bulkheads at Gallipolis, Emsworth, and Winfield dams. Each bulkhead unit is 127.5 ft long by 12.5 ft deep by 4.33 ft high, and weighs 28 tons. Each is capable of resisting water pressure on a strip 4.33 ft high by 127.5 ft long under an average head of 28 ft. The prime consideration here was reduction in weight, since the bulkhead units are to be handled by a whirler derrick boat at a radius of 117 ft.

Another recent application of Alloy 27S-T is in the flood bulkheads provided for the railway and highway openings in the levees and river walls at Huntington, W.Va. These bulkheads consist of timber stop logs, braced by 27S-T frames. The openings are about 36 ft wide and the closure gates must resist water heads of from 10 to 20 ft. As the gates may have to be erected by man power under the most unfavorable conditions of rain, wind, and ice, light weight is of extreme importance.

A Bridge Builder Looks Back

Recalling Significant Details, Both Personal and Technical, of a Long Engineering Career

By Otis Ellis Hovey
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"FROM Farm Boy to Honorary Member" this story might be captioned. Such a title has a familiar ring. It would do credit to Horatio Alger himself—with the important distinction that this is a true story. What a father could not have himself, he coveted for his son. And what is even more important, he gave the boy those qualities of heart and mind to attain the goal. Times change; many of the hardships of yesterday seem now almost legendary. But the lessons of the past, as evidenced by Dr. Hovey's reminiscences, are inspiring still. To-day as of old "our men may copy their virtues bold."

HOW did I happen to become an engineer? The tendency was born in me.

My father attended one of those sterling Vermont academies, the head of which was a great teacher who had a passion for mathematics and surveying, and a strong personality and character that impressed his ideals upon his pupils. The result was that Jabez Wadsworth Hovey taught school winters, and made compass and odometer surveys of some Vermont counties summers. Railroad construction then was advancing rapidly and he wanted to enter that field, but circumstances at home made it necessary for him to stay on the farm.

When I was about eight years old, a railroad was being constructed through our town, and when opportunity afforded, my father would take me in a buggy to where work was under way. Naturally, I was particularly attracted to the surveying party. I understood the reason for tripods by analogy to milking stools, but the mysteries of the shining instruments on top of them, and the wonderful rod up and down which a beautiful red and white target could be made to slide, bewitched me. Then and there, I knew that I must learn more about them, why they were used and what they accomplished. This idea stayed with me—together with a profound dislike for the animals that made dairy farming possible in a state principally adapted to this type of agriculture.

When circumstances indicated that it might be possible for me to attend college, with my father's guidance I decided not to go to the State University, where a degree of civil engineer was then given at the end of three years. Instead I entered the Chandler Scientific Department of Dartmouth College, where four years was required for a bachelor's degree, and two years of postgraduate study to qualify for the coveted degree of civil engineer.

At the end of the college course I decided to gain some experience before taking the two years of postgraduate work. My first real job was as engineer of a railroad 13 miles long and 3 ft wide in the Deerfield Valley from Hoosac Tunnel, Mass., to Readsboro, Vt., which was built by the Newton paper companies of Holyoke. During two construction seasons I was constantly trying to find a more important railroad connection when, early in the second summer, I found that I would have to design a highway bridge about 80 ft long to be built in exchange for some right of way. My earlier studies had not taken me very far into the theory of stresses and design, and so many a long summer evening had to be spent in perspiring and uncertain struggle.

My first idea was to use a through Howe truss design, and this I quite fully developed. The bill of material called for a variety of sawn timber, iron tension rods, bolts, and angle blocks, and the framing required precise workmanship, making the cost too great. One day, passing through the sawmill lumber yard, I saw piles of 3 by 10-in. spruce planks which had accumulated because of a lack of customers. I changed my design to a Towne through lattice truss, and the bridge was built of 3 by 10-in. planks with wooden pins at all intersections. This pleased my employer and he told me that I might become an engineer after all.

My struggles with this structure having convinced me how little I knew about bridges, I began to search for a place where I could learn something about them. I found a position as draftsman with the Edgemoor Iron Company at Wilmington, Del., and began work at about half the pay I had received from the railroad. At that time Edgemoor had one of the best fabricating shops in the country, and the office was noted for the excellent experience that could be gained there. College graduates flocked to it, and one was associated with young men of the best type. The late George H. Pegram, Past-President and Honorary Member of the Society, had been chief engineer of Edgemoor for several years, but had left to enter private practice some two years before I joined the staff. He had built up a small but able staff and had encouraged the best in design and fabrication thus adding much to the reputation of the company.

The first bridge for which I made a part of the drawings was the Rulo Bridge, designed by the late George S. Morison, Past-President of the Society. This design was so much better in many ways than others in the office files that I made up my mind to work with him if it became possible. But in the meantime, what about that postgraduate course? I began to make plans to resign and go back to school. I talked it over with the late Onward Bates, afterward President and Honorary Member of the Society, who was then chief engineer of the company. He approved of my plan, but when my next pay was handed to me it was 50 per cent larger than previously. Many years later, Mr. Bates told me that while he thought the increase was deserved, he had given it to me partly to find out whether I really meant to take the postgraduate work.

I returned to Dartmouth in the fall of 1887, and had to pass an entrance examination so long and difficult that it stands out in my mind to this day as a major accomplishment.

One day in February 1888, I read that an old dam had been washed out at Chicopee, Mass., and that the late D. H. Tower of Holyoke, Mass., had been appointed engineer on a new masonry dam. I took a train to Holyoke that afternoon and came back in the early morning of the next day engaged as his assistant for the season of 1888. The work at the dam did not require all my time, and during the summer I had charge of work on paper mills in Holyoke, Westfield, and Dalton, Mass., and at

THE BELLEFONTAINE BRIDGE—MISSOURI RIVER CROSSING OF THE CHICAGO, BURLINGTON & QUINCY RAILROAD NEAR ST. LOUIS

Completed in 1893, This Was the First of Morison's Bridges to Incorporate Rigid Sway Bracing. Dr. Hovey, as Chief Draftsman, Designed the Superstructure. This View Shows the First Train Across the Bridge. The Structure Is Still in Service, Carrying Heavy Modern Rolling Stock

Bennington, N.H. The next fall I returned to the Thayer School, a month late.

About the middle of February 1889, a telegram came to the late Dr. Robert Fletcher, M. Am. Soc. C.E., Director of the Thayer School, asking him to recommend an instructor in civil engineering at Washington University, because of the illness of the late Prof. J. B. Johnson, M. Am. Soc. C.E. I received the appointment and started that night for St. Louis. Professor Fletcher magnanimously allowed me to continue my work at the Thayer School—reporting, sending my thesis, and answering examinations by mail—so that I graduated with my class in June 1889.

The first half year and the following complete year of teaching were busy times. In addition to a heavy schedule of teaching, I had charge of the testing laboratory, where considerable commercial work was done in addition to demonstration work with students. Also, I did the indexing of periodical engineering literature for the Associated Engineering Societies, which had been started by Professor Johnson. The first summation volume, published in 1891, was the predecessor of other volumes and of the present Engineering Index. This experience in teaching was most stimulating. To understand a subject fairly well is one thing; to convince a group of students that one is master of it is quite another.

FIVE YEARS WITH GEORGE S. MORISON

During this time I kept in correspondence with Mr. Morison, and in April 1890 I was definitely engaged by him and resigned my teaching position. In June, I reported at Chicago for work and was sent to Detroit to make a survey for a proposed railroad bridge across the Detroit River, including a study of shipping on the river, borings in the river bed, and the location of the two approaches on land. The shipping survey required a determination of the position where vessels passed across the line of the bridge when moving up and down the river, also the height of the highest mast of each vessel. It happened that most of the large boats moved through the river at dawn and at dusk. My hours on duty, therefore, required rising at about 2:30 a.m. and retiring at 9:30 p.m. These long hours continued for nearly three months. There were no arbitrary limitations on working hours in those days.

On completion of the survey I went to the Chicago office to analyze the results and to design the bridge. Imagine my surprise when, without previously intimating his intention, Mr. Morison announced to the staff that I was to take charge of the office at once, my predecessor, Ralph Modjeski, M. Am. Soc. C.E., having been promoted to more important work.

Then followed more than five years of the closest association with the man whom many considered to be the leading bridge engineer in the United States. Mr. Morison was a man of the highest character and great ability. Incidentally, he wore about a number $8^1/_2$ hat, and his enormous head was packed with ideas. He had great executive ability, and having studied and practiced law before he took up engineering as a career, he had unusual knowledge as to how business should be conducted. He was a hard man to work for until one became familiar with his methods and learned that he had no patience with a "yes" man. One had to stand upon his own feet and frequently to fight for his ideas of design when he thought them to be correct. One peculiarity of his was that he disliked having a design or a detail submitted to him until it had been thoroughly worked out. Any quickly presented preliminary notion always was wrong, however right it might become later.

During this period my work included the design of the approaches of the Memphis Bridge; the Bellefontaine, Alton, and Leavenworth bridges; many smaller truss bridges; and a large number of plate girders. In connection with the entrance of the Chicago, Burlington, and Quincy Railroad into St. Louis, the yard in North St. Louis, with its incidental structures, a street bridge, and the freight and passenger stations, were designed under my charge. The last bridge I designed for Mr. Morison was a four-track, Bélidor-type, bascule struc-

ture, in two parallel two-track units across the Chicago River, for the Chicago and Northern Pacific and Union Stock Yards Company. Also, I was resident engineer during its construction.

The years spent with Mr. Morison probably did more toward my development as an engineer than any other similar period. The contact was highly stimulating; the work was fascinating; and there was plenty of it. One tried constantly to anticipate him in the development of new ideas and it was a great satisfaction to do so at times. Everything had to be done the best we knew how and the best was never quite good enough; and "time was of the essence of the contract."

The panic of 1893–1895 nearly stopped large engineering work for a time, and the considerable staff of field and office engineers dwindled until there were only two of us left. I then resigned, having procured a position as engineer of the Union Bridge Company, which had an office in New York and a shop at Athens, Pa. The Union Bridge Company of the 1890's was the successor to the company of the same name organized in 1884 by Charles Macdonald, Thomas Curtis Clarke, George S. Field, Edmund Hayes, Charles Stewart Maurice, and Charles Kellogg. All but Clarke were members of the American Society of Civil Engineers and he joined later. There were giants in those days!

This company had built many of the bridges designed by Mr. Morison and had an old shop, with some good, and more old, tools and machines, but the finest group of men in the shop that I ever knew. They had grown up in the business, were fine mechanics and workmen, and did not seem to know how to do bad work. Each group of men had three or four potential foremen in it. My duties often took me into the shop, and it was a great satisfaction to see the enthusiasm of the men and the cheerful way they went about their work. This company, which now would be considered small, had some assets that would be envied today: the ability to select the work it wanted and to get it, determination to do the work well and to get well paid for it, and a fine personnel.

In 1898, I went to England and was fortunate to find that more than three hundred small railway plate girder bridges were needed in the Orange Free State. They had been designed in the typical English manner. All holes were to be drilled with parts assembled, the parts match-marked, and the bridges painted all colors of the rainbow for identification. We obtained the order but with the girders redesigned to fit American shop practice, with all field holes reamed to templates, and all similar parts interchangeable. A delay made it necessary to store the steel in Africa for nearly two years. All marks rusted away, and the engineers were amazed to find that all they had to do was to select the proper parts for a bridge from the pile, and that then all the open holes fitted perfectly.

Up to the time of my association with the Union Bridge Company, practically all my work had been in the direct interest of the owners and their representatives. Beginning at this time, however, and continuing for many years, my work was that of an engineer for establishments which depended upon profits for their existence. A new type of problem was encountered, involving the economics of design, manufacture, and construction. There is quite a difference between specifying how work is to be done and actually doing it economically. It is my experience that the latter calls for clearer thought and more arduous effort than the former. Work with a small fabricating company has some advantages. The engineer comes in intimate contact with all phases of contracting, designing, fabrication, and erection, and makes excursions into cost accounting and finance. It was a broadening experience and an excellent preparation for what was to follow.

ENLARGING THE PIN HOLES OF THE WILLIAMSBURG BRIDGE—RECALLED BY DR. HOVEY AS ONE OF HIS MOST DIFFICULT JOBS

The Boring Machine, Driven by the Electric Motor, Is at the Lower Right

FORMATION OF AMERICAN BRIDGE COMPANY

In 1900 several steel fabricators combined to organize the American Bridge Company. The Union Bridge Company joined in this enterprise and I continued my work with the new company. I shall never forget those arduous months when we were trying to forget the old conditions and learn to adapt ourselves to the new. Fortunately, I was young enough to go through this strenuous time without breaking, but had the adjustment come later in life it might have proved a more serious matter. Gradually we learned to know each other better, the difficult conditions disappeared, and we settled down into better relationships and became a happy family. The passing years bring many changes, among them severance from active association with old friends, and I look back on my long service with the American Bridge Company as among the happiest periods of my life.

How little a young man can predict at graduation and the beginning of an engineering career where circumstances and experience will lead him! I started out to become a railway engineer but most of my life has been spent on bridges and other steel structures. I began as what is termed a civil engineer, but circumstances determined that mechanical engineering should play an equally important rôle in my career. I had always been interested in moving structures, and the time came when it seemed necessary to try to simplify and unify practice in the design and construction of movable bridge machinery, which varied greatly at different plants.

This I did by issuing a series of notes from time to time over a period of several years, on the design of heavy, slow-moving machinery, and introducing their use in the several designing offices. Some of these notes, together with many other data, I later had published in two volumes entitled *Movable Bridges*. Early in 1891, I was assigned to design my first swing bridge machinery. I found some data on relatively light, rapidly moving mechanisms, but none were available on equipment suited to my purpose. The struggle to solve this first, and several succeeding problems of similar nature, made

me decide to try to treat this subject for the benefit of younger engineers as soon as experience might warrant such an attempt. All my spare time for several years was devoted to the preparation of the manuscript of this book. Undoubtedly I received far more benefit from preparing it than any reader will ever gain from it.

In 1904, I visited London and Constantinople to investigate trade conditions in the Near East and to study a project for bridging the Golden Horn. I designed a pontoon bridge for the purpose, but it was not built at that time because no way could be found to finance it.

SPECIAL BORING MACHINE FOR WILLIAMSBURG BRIDGE REPAIR
This Equipment Required Just One Hour to Enlarge a Pin Hole from 10 to 13 In., Reaming Out 1,300 Cu In. of Steel and Simultaneously Smoothing the Hole for a New Pin

An engineer for a fabricating company works under some disadvantages. It often happens that his most arduous and important work is done in a kind of confidential relationship with customers. They must be proved to be right. If something has been designed that should not be built in its original form, and if the engineer for the fabricator must make changes in it to render fabrication and erection more practical and economical, he cannot take public credit, however much he may have improved the structure. He must do his job and not advertise his prowess. The credit must go to the engineer employed by the owner. Many such cases occur in connection with which the contractor's engineer is sorely tempted to talk or to write about the obstacles that were overcome, and the improvements that were made, but it is bad business to do so.

I have sometimes been asked what were the most difficult engineering jobs I ever did. The answer is, strengthening and repairing two bridges without stopping traffic on them.

One of these problems was in connection with the strengthening of the Williamsburg suspension bridge in New York City, in 1914. An approach span at each end of the main span is supported at one end by a pin connection to the cantilever end of the stiffening truss which extends one panel behind the tower. It was necessary to enlarge the pin from 10 to 13 in. in diameter, connect some new members, and do the work with a minimum of interruption to traffic on the bridge. Only one hour at each connection was allowed for enlarging the pin hole, and within that time 1,300 cu in. of steel had to be reamed out and a smooth hole produced for the insertion of the new pin. A special boring machine was designed and built that had a cutting head fitted with six cutting tools and one finishing tool. The rotating shaft was provided with differential gearing at one end which drove the cutting head by a screw and advanced it a definite distance with each rotation of the boring bar. An important part of the work was to lock the members meeting at the joint to prevent all movement and to provide for the stresses in such a way that the pin could be taken out without danger to the bridge. The work was done in the early morning hours and proceeded without incident. Each pin hole was bored in an hour or, in one case, in as much as three minutes less.

After one has finished some unusually difficult task, sometimes it is some relatively minor detail that leaves the keenest feeling of satisfaction. In this case, it was estimating the power required to drive the machine and the boring head, with its seven tools, within 1 hp of that calculated from electrical readings taken during the operation. The difference was about 3 per cent.

The other bridge strengthening problem was to renew four large counterweight sheaves on a vertical-lift span which had a double-track railway on the lower deck and a highway with two sidewalks on the upper deck. The original structural steel sheaves were failing around the trunnions, which passed through them, because of the light construction of the parts intended to serve as hubs. Temporary sheaves were placed between the old ones and supported on cross girders that had to be strengthened in order to carry the loads on the sheaves in the new position. Temporary counterweight ropes were installed and the weight of the bridge and counterweights transferred to them so that the bridge still could be operated. The old sheaves, trunnions, and bearings were then removed and new ones installed in their places, after which the process was reversed and the loads were shifted from the temporary equipment to the new. This was done without interference with traffic—except for an hour on one occasion.

The design and construction of new work can be controlled by the engineer, but in strengthening and repairing he must adapt his schemes to conditions already fixed by the existing structure. Often this demands far more thought and ingenuity than the planning of new work.

THE SATISFACTIONS OF ENGINEERING

After having followed the profession of engineering for more than fifty years, one is tempted to look back and try to assess the satisfactions of such a career. Years ago, several of us were together at a time when conditions were none too favorable. One and another had complained about phases of their experience and expressed dissatisfaction with the profession. Last of all, I was asked what I thought. I gave a Yankee answer by asking each of them what career he would choose if he could be set back in the middle of his college course, still in possession of some of the knowledge he had gained by experience. The answer in each case was "engineering," and it is easy to see why.

A successful engineer must possess and develop a high type of character. He must be meticulously honest with himself and with others. He must be obedient to the laws of nature so far as he can grasp them. He must be logical, thorough, industrious, inventive, practical, firm in well-grounded opinions, yet tolerant of the views of others and able to associate comfortably with them. At the same time, he must see visions and dream dreams, and clearly visualize the embodiment of his dreams, whether in structures, machines, organizations, business, or human relationships. Given the right temperament, abilities, and training, it is difficult to choose a more attractive profession. New problems challenge solution, and monotony is almost unknown. There is keen satisfaction in seeing visions realized. One's daily occupation reacts favorably on the development of character and personality, and he has a wonderful time as long as he is able to think and work.

While the financial rewards may not be large, the inner satisfactions are great. The engineer feels that he has at least done a little to advance civilization and the enjoyment of life by his friends and the public in general. As a career, and a culture, it seems to me that the engineering profession leads all others.

Engineering Aspects of the Influence of Forests on Mountain Streams

By Richard A. Hertzler, Jun. Am. Soc. C.E.

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Fig. 1. A 120-Deg V-Notch Weir Installation, with Silting Basin, Ponding Basin, and By-Pass

In progress at the Appalachian Forest Experiment Station, near Asheville, N.C., is a comprehensive investigation of the influence of forests on mountain streams. The objectives and methods of these studies, and some of the results to date, are outlined in the accompanying article. Of particular interest are the descriptions of the special stream-gaging devices, the data on the degree of stream control afforded by forest cover, and the conclusions in regard to infiltration capacity of forest soils. Mr. Hertzler's paper was on the Hydraulics Division program at the 1939 Spring Meeting.

In the broader sense, the purpose of the investigations now in progress at the Appalachian Forest Experiment Station is to determine the effects of forests on water and land resources as they relate to social and economic problems. Of the many phases of research falling under this head, investigations to determine the effects of forests and forestry practices on erosion control and runoff present the most interesting engineering aspects. The purpose of this phase of the investigation is to establish principles and practices of forest land-use, consistent with recognized sound methods, which will increase the quantity and quality of usable water, decrease flood flows, and control erosion.

To arrive at a practical scientific solution of these problems involves a clearer understanding of the basic laws underlying the entire hydrologic cycle than can be obtained from existing data. This is especially true of the phenomena of runoff, ground water, microclimate, and erosion processes.

Numerous experimental drainage areas have been established within several forests and in neighboring agricultural areas for the purpose of obtaining sufficient data to supply this requisite information and also to determine the relation between these phenomena and vegetative cover conditions. In the selection of the areas due consideration was given not only to vegetation but to physiography, geology, soils, and climate as well, so that the results would be as closely as possible representative of the region. Many engineering problems were encountered in the design of the experiment as a whole and in selecting the location, type, and size of stream gage to be used for individual drainages.

Special Gaging Devices Developed

For small streams in forested areas there was a need for a gaging device with a greater capacity than a 90-deg V-notch weir, but with accuracy at low flows and with provisions for measuring deposited material from undisturbed forest land. To meet these requirements the 120-deg V-notch weir installation shown in Fig. 1 was developed. (A detailed description of this device was given by the writer in Civil Engineering for November 1938.) Other types of sharp-crested weirs are also used where the quantity of silt does not impose prohibitive maintenance costs.

Within the experimental area at Copperhill, Tenn., essential requirements of a gaging device are (1) that it must pass large quantities of silt, and (2) that it must measure the rapid storm runoff from completely denuded drainages. For these areas the San Dimas flume, as developed by the California Forest and Range Experiment Station, was used. (For description of this flume see "Measurement of Debris-Laden Stream Flow with Critical-Depth Flumes," by H. G. Wilm, J. S. Cotton, and H. C. Storey, Transactions Am. Soc. C.E., Vol. 103, p. 1237.) Fig. 2 shows a typical installation with an entrance radius equal to twice the width of the flume and the floor on a 3-per cent slope. The head is measured in a stilling well into which water passes through a vertical slot placed downstream from the critical depth. This type of installation has proved very satisfactory.

For general purposes a modified Columbus type 1-A deep notch control has been recently developed (Fig. 3) and is now being rated in the National Bureau of Standards Hydraulics Laboratory. Provided the ratings are satisfactory, it will be used for many of the future installations. Its advantages are a non-silting ogee control, accuracy for a wide range of discharge, and a predetermined rating table.

A definite need for well studies was realized early in the investigations, so numerous ground-water wells, as illustrated in Fig. 4, have been constructed. Whenever possible, they are equipped with recording gages. Well data have thrown much light on the ground-water discharge to streams and also on methods of separating ground-water flow from storm flow for analyzing the hydrograph.

After the data from the installations are collected, assembled, and checked in the field, they are sent to the office for compilation and study. Precipitation, runoff, and the associated data are analyzed by six-month periods, corresponding to the growing and dormant seasons, to show the general characteristics of each of the 39 streams now under investigation. At the present stage of data analysis, certain trends are already indicated, and in some investigations definite results have been obtained. A few examples of these derivations, which involve engineering principles in the analysis and have definite engineering application, will be presented in the following paragraphs.

Typical Analyses and Applications

Land-Use–Runoff Relations. From 1,550 observations of storm hydrographs on areas of different types of land-use, a frequency distribution curve of peak discharge has been prepared (Fig. 5). Data were obtained from drainage areas of the Coweeta and Bent Creek Experimental Forests and from the Copper Basin, Tenn., and include storms of 0.5 to 6.0 in. of total precipitation, varying in intensity from 0.01 to 4.26 in. per hour. The curves of Fig. 5 show separately the data from denuded lands, overgrazed pasture, abandoned farmland, and forested drainages. Taking runoff from forested lands as unity they indicate, for example, that for 10-per cent frequency of all the storms over $^1/_2$ in., abandoned farmland, overgrazed pasture, and denuded lands

FIG. 2. A 2-FT SAN DIMAS FLUME IN THE COPPER BASIN EXPERIMENTAL AREA, TENNESSEE

FIG. 3. A MODIFIED COLUMBUS TYPE 1-A DEEP NOTCH CONTROL TO MEASURE FLOW FROM SMALL DRAINAGES

produce peak discharges respectively 12, 24, and 47 times as great as forest land. Curves of this type aid in predicting flood flows, are useful in designing hydraulic structures, and are applicable for other engineering purposes within areas of similar geology.

Six-month summaries of stream discharges form another basis for comparing stream behavior. The example shown in Table I is for the dormant season from November 1, 1936, to April 30, 1937, for streams of uniform forest cover on the Coweeta area in Macon County, North Carolina. The table contains discharges in cubic feet per second per square mile, broken down for each stream into total runoff, seepage, or ground-water flow, and storm flow. Similar tables for the entire period of record indicate that seepage flow as a percentage of precipitation increases with the area. Expressed as a percentage of runoff, seepage flow varies from 86.6 to 91.3, while storm flow varies from 8.7 to 13.4. The high seepage flow along with the corresponding low percentage of storm flow is an indication of the extent of control afforded by the vegetative cover. Records for overgrazed pasture and denuded and abandoned agricultural lands show a higher percentage of surface runoff and a lower percentage of ground-water or seepage flow than do these forested areas.

TABLE I. DISCHARGE OF STREAMS IN COWEETA EXPERIMENTAL FOREST

Six-Month Summary—November 1, 1936, to April 30, 1937

			RUNOFF					SEEPAGE FLOW			STORM FLOW		
AREA SQUARE MILES	STREAM No.	PRECIPITATION INCHES	Maximum*	Minimum*	Mean*	Inches	% of the Precipitation	Mean* (Base-flow)	% Run-off	% of the Precipitation	Area Inches	% Run-off	% of the Precipitation
0.007	5	44.37	37.14	1.190	3.807	25.621	57.7	3.392	89.1	51.4	2.793	10.9	6.3
0.016	4	42.85	31.343	1.709	5.701	38.375	90.0	5.174	90.8	81.7	3.530	9.2	8.3
0.034	6	43.81	27.01	0.658	3.171	21.343	48.7	2.822	89.0	43.3	2.348	11.0	5.4
0.036	3	42.01	21.643	1.008	2.540	17.101	40.7	2.200	86.6	35.2	2.292	13.4	5.5
0.048	2	40.32	18.217	0.557	3.189	21.466	53.2	2.885	90.5	48.2	2.039	9.5	5.0
0.061	1	40.19	13.289	0.593	2.664	17.928	44.6	2.390	89.7	40.0	1.846	10.3	4.6
0.227	7	40.28	16.100	1.016	3.646	24.544	60.9	3.329	91.3	55.6	2.135	8.7	5.3
0.332	10	42.13	20.712	1.273	4.362	29.363	69.7	3.901	89.4	62.3	3.112	10.6	7.4
2.794	9	49.20	41.990	1.575	5.267	35.456	72.1	4.596	87.3	62.9	4.503	12.7	9.2
2.932	8	44.45	29.865	1.383	5.837	32.426	72.9	4.212	87.4	63.7	4.086	12.6	9.2

* Cubic feet per second per square mile.

Until more of the hydraulic, hydrologic, and meteorologic variables can be segregated, land-use–runoff relationships can best be studied on plots and small drainages where many of these variables can be completely eliminated. To apply results from plots to small drainages and from small drainages to large ones is a problem that has not been completely solved. However, recent data have thrown much light on the problem to the extent that results from plots and small drainages can be used to predict flood flows more intelligently. This is a valuable contribution when viewed in the light of extensive flood control programs now in progress.

Infiltration Capacity. Although in recent years engineers have done much to illumine the concept of infiltration capacity, even to the point where it can be quantitatively determined with considerable accuracy for large drainages, it still remains a perplexing problem.

While analysis of runoff and precipitation data at the Appalachian Station has not as yet produced conclusive results, it has led to a clearer understanding of this phenomenon. The undisturbed, deep soils of forested areas have a very high infiltration capacity; in fact, it is questionable whether this capacity is ever exceeded by rainfall intensity.

HYDROGRAPH ANALYSIS OF INFILTRATION

An example of a hydrograph analysis to determine infiltration is presented in Fig. 6. The curve marked "observed runoff" is the storm hydrograph obtained from a continuous water-level recorder chart. The curve marked "mass precipitation" is a reproduction of the storm rainfall record from a float-type precipitation gage, subsequently corrected by subtracting 10 per cent because studies conducted by the Station show that this amount is intercepted by the vegetation covering this drainage.

Ground-water is separated from observed runoff by the following method:

1. A normal depletion curve of ground-water discharge is obtained for this stream by tracing all existing records in such a manner as to eliminate stream rises.

2. The normal depletion curve is fitted to the recession side of the hydrograph (labeled "observed runoff" in Fig. 6) and extended backwards to some point beyond the time of observed peak runoff.

3. The accretion side of the ground-water flow curve is obtained from recorded ground-water elevations in a well, correlated with known discharge rates. The points of known discharge rate are (1) on the observed runoff curve at the beginning of the stream rise (0.051 cu ft per sec at 6:40 p.m., Fig. 6) and (2) on the extended ground-water depletion curve at the time of the peak on the ground-water stage hydrograph. The determination of this second point is based on the assumption that the peak ground-water discharge occurs at the time of the maximum ground-water elevation. In the example illustrated by Fig. 6, this time, taken from a recorded ground-water stage hydrograph (not reproduced here) was 3:45 a.m. With these two points of known ground-water discharge, the recorded ground-water stage hydrograph can be converted into the discharge hydrograph labeled "ground-water flow" in Fig. 6. (In the example shown, the ground-water rise, which was very slight, occurred at the time the observed runoff returned to normal. For winter storms, with more moisture in

FIG. 4. GROUND-WATER WELLS FOR DETERMINING ELEVATIONS OF THE WATER TABLE

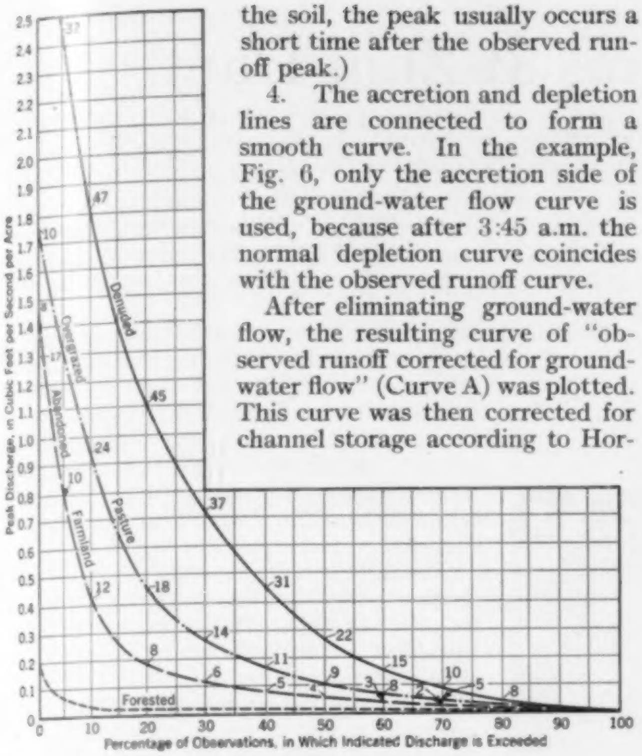

FIG. 5. FREQUENCY DISTRIBUTION OF PEAK DISCHARGES ON SMALL WATERSHEDS WITH VARIOUS TYPES OF COVER

Based on 1,550 Individual Storm Hydrographs on 21 Watersheds of 4 to 1,859 Acres in the Southern Appalachians

the soil, the peak usually occurs a short time after the observed runoff peak.)

4. The accretion and depletion lines are connected to form a smooth curve. In the example, Fig. 6, only the accretion side of the ground-water flow curve is used, because after 3:45 a.m. the normal depletion curve coincides with the observed runoff curve.

After eliminating ground-water flow, the resulting curve of "observed runoff corrected for ground-water flow" (Curve A) was plotted. This curve was then corrected for channel storage according to Horton's method[1] resulting in the curve "observed runoff corrected for ground-water flow and channel storage" (Curve B). Curve B, in turn, provides the data for plotting the "mass surface runoff" curve. Finally, surface detention and mass infiltration determined by Horton's method,[2] also surface detention and mass losses determined by Sherman's method,[3] were plotted. The difference, both in infiltration and in surface detention as computed by the two methods, can be seen by examining the curves. Apparently neither method is completely satisfactory for an infiltration analysis under the observed conditions.

This interpretation of infiltration capacity is substantiated by field observations and also by plotting precipitation intensity against infiltration capacity obtained by Sherman's and Horton's methods, in which cases the resulting graph is nearly a 45-deg line.

CORRELATIONS BETWEEN DISTRIBUTION GRAPHS AND BASIN CHARACTERISTICS

Unit-Graph Analysis of Runoff. The unit-graph principle has been investigated as a possible method of analyzing runoff from small drainage basins. The investigation of from 2 to 6 unit-graphs for each of 22 drainages revealed certain correlations between the shape of the distribution graph and physical characteristics of the drainage basin. These correlations are as follows:

1. For comparable forested areas peak percentages of runoff consistently decrease as the drainage area increases.
2. The width of the bases of the distribution graphs increases with the area.
3. The effects of vegetative cover are reflected in the peak percentage and widths of the distribution graph.

In connection with this study, pluviographs also revealed marked trends such as:

1. Runoff coefficients to be applied to the pluviograph increase with accumulated rainfall.
2. Rainfall intensity variations have a greater effect on small, lightly vegetated areas.
3. The effect of previous rainfall on the surface-runoff coefficient is greatly reduced after a break of several hours in surface runoff.

While this analysis has not yet been completed, it shows that the unit-graph principle affords a sound method of investigating land-use–runoff relations on small drainage basins.

The Appalachian Forest Experiment Station, under the directorship of Dr. R. E. McArdle, is one of twelve forest experiment stations maintained by the Forest Service of the U. S. Department of Agriculture. Dr. C. R. Hursh is in charge of the forest influence studies for this station.

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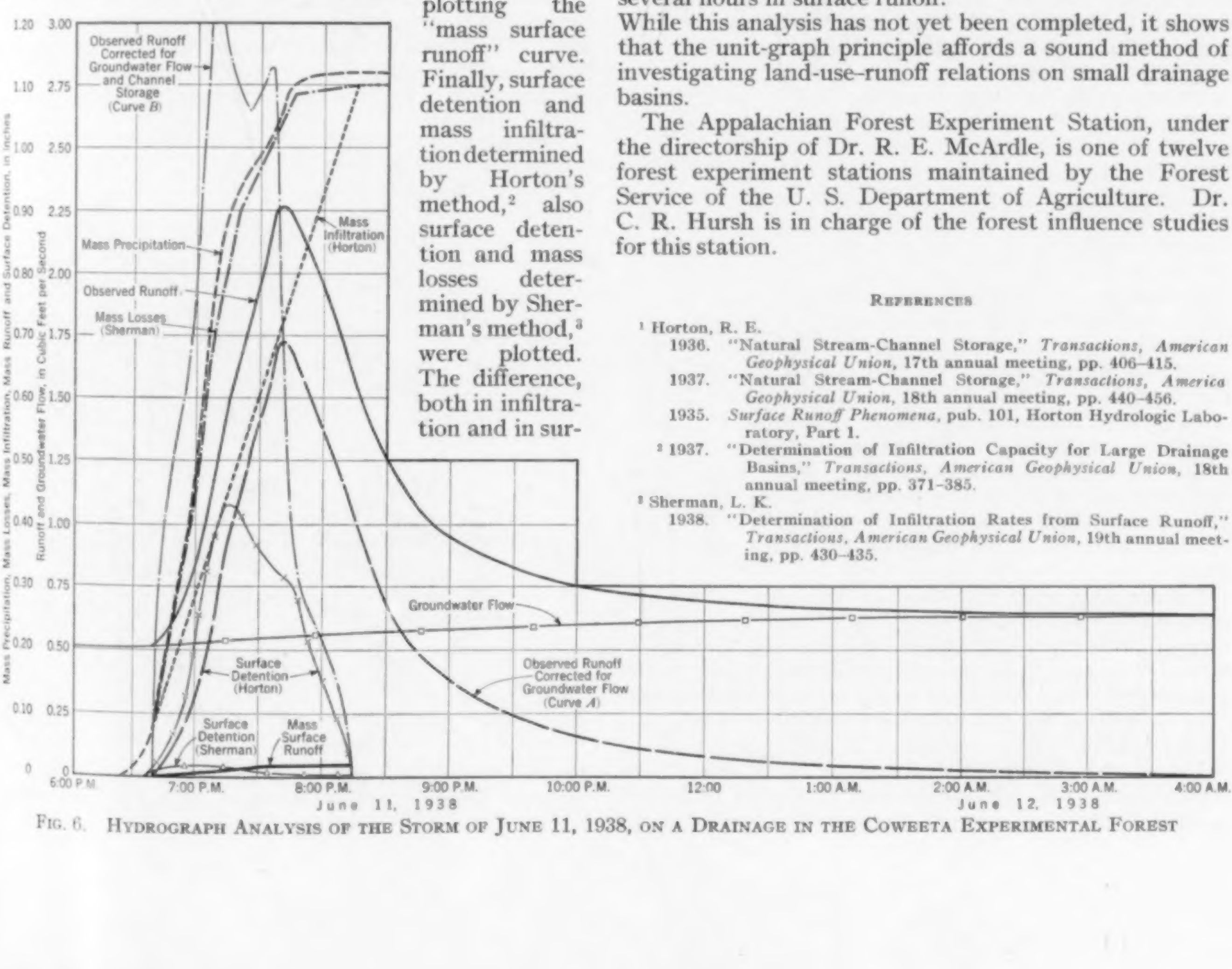

FIG. 6. HYDROGRAPH ANALYSIS OF THE STORM OF JUNE 11, 1938, ON A DRAINAGE IN THE COWEETA EXPERIMENTAL FOREST

Abutment Problems at Zuni Dam

By Edwin B. Eckel

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Recently completed repairs to the Zuni Dam, in New Mexico, have ended, it is hoped, a long series of difficulties with its abutments. The dam itself is small and comparatively unimportant in this era of gigantic structures, but it is an excellent example of the fact that no dam can be any better than its natural foundations. Furthermore, it serves to give point to the need for adequate geological examination of all prospective dam sites.

Downstream Side of Zuni Dam, Looking Toward South Abutment
The Present Spillway Appears in Middle Distance

The dam (Fig. 1), which is on the Zuni River, at Black Rock Agency—4 miles east of the Indian town of Zuni and 40 miles south of Gallup—was built in 1904–1907 by the Indian Irrigation Service, at a total cost of $280,759. It is a combination rock- and hydraulic-fill structure, 80 ft high and 500 ft long at the crest. The original reservoir capacity of 16,000 acre-feet has been reduced by silting to about 3,000 acre-feet. It is expected that two recently constructed silt-detention dams above Black Rock will retard further silting.

Storage began in 1908, and the reservoir filled completely in August 1909. On September 5, 1909, when the water had reached spillway level, several small leaks developed at the north abutment. These were stopped almost immediately by the use of sand-bags. Later, a heavily riprapped earth blanket, with a minimum thickness of 10 ft, was constructed along the north abutment. These repairs proved entirely effective, and no leaks have since developed on the north side of the dam.

On the day after the leaks on the north abutment were discovered, a larger and much more serious leak broke out on the south abutment. This led to destruction of the concrete-lined spillway, injured the end of the dam slightly, and produced many cracks and sinkholes over an area of about 7 acres on the abutment (Fig. 2). The maximum outflow was about 5,000 cu ft per sec.

During the period 1910–1912 there was constructed a 705-ft cutoff wall, which was tied to the hydraulic-fill portion of the dam, crossed the spillway, and extended 450 ft farther south (Fig. 2). This structure was about 50 ft high and consisted of steel sheet piling surmounted by a masonry wall. The spillway was rebuilt at the same time.

Except for two or three minor leaks that were easily stopped with sand-bags, the cutoff wall was effective until April 1936, when a new leak developed—similar to that of 1909, though the greatest flow was less than 500 cu ft per sec. All the stored water was lost, but the only apparent damage to the structure was a slight settlement of the extreme south end of the cutoff wall.

The dam is built in a narrow and rather shallow gorge that has been cut through a basaltic lava flow, the approximate distribution of which is shown in Fig. 1. This lava stream extended down the broad and shallow Zuni Valley, which had been originally cut in red shales and sandstones and then largely filled with alluvium. Near the site of the present dam, the lava followed the curving course of the stream, forcing it farther to the south and damming it for a considerable period. A shallow lake was formed, the overflow of which cut a new channel in bedrock to the south of the present gorge.

Eventually the Zuni River cut through the lava, largely by undermining, and formed the gorge at Black Rock. The present valley, therefore, has developed fairly recently although it is in valley fill that antedates the lava flow. The flow is 30 ft thick at the dam site,

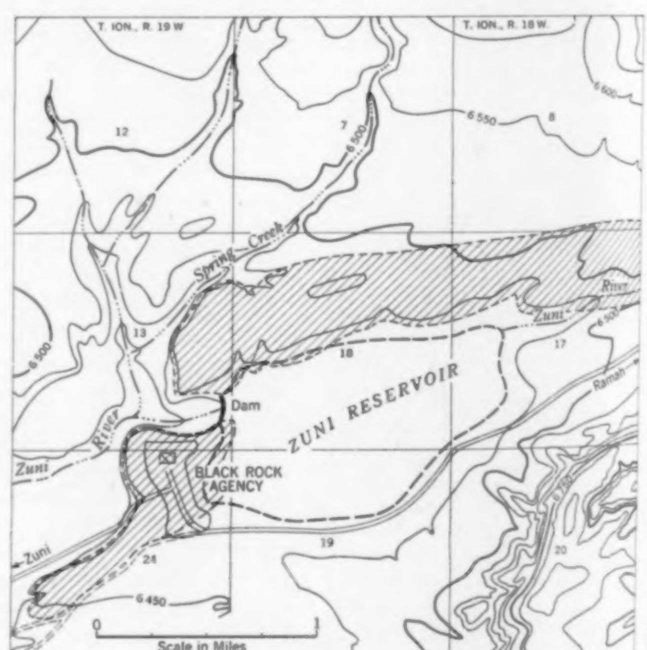

Fig. 1. Topographic Map of Zuni Reservoir and Vicinity, Showing Distribution of Basaltic Lava Flow. Contour Interval 50 Ft

and elsewhere ranges from 5 to 50 ft in thickness. The top of the flow is vesicular, while the lower parts are massive in most places. Locally the rock is strongly but irregularly jointed.

Excavations made after the 1909 break showed that in the abutments the lava is underlain by a regular series of horizontally bedded sand, clay, and loam strata. Immediately beneath the basalt is a layer of loose sand from 4 to 8 ft thick, underlain by several feet of tough red clay. Blue clay forms the valley floor.

CAUSE OF THE PARTIAL FAILURES

The partial failures in 1909 and 1936 were due to processes similar to those that caused the formation of the gorge at Black Rock. In 1909, when water in the reservoir was at spillway height, it stood 24 ft above the base of the lava flow. It was thus possible for it to enter openings in the exposed basalt, and to reach the layer of loose sand beneath, under considerable head. This sand was confined between the lava and the underlying bed of clay, but was not confined along the edge of the cliff below the dam. It thus acted like a broad, flat pipe, conducting the reservoir water to an exit below the dam. The sand was rapidly eroded and flushed out, leaving large openings that allowed the spillway and lava cap to crack and subside. The pattern of the cracks and sinkholes which developed (Fig. 2) indicates clearly the course taken by the water beneath the abutment.

The break of 1936 was like that of 1909, except that the water was forced to travel around the end of the cutoff wall before it could find an exit. It thus moved about 1,000 ft, whereas in 1909 it had moved only 200 to 600 ft. Some of the water passed through material that had been disturbed by the earlier leak, but the new crack pattern (Fig. 2) suggests that it was easier to take a new course through undisturbed ground.

Except for the area near the end of the cutoff wall, the clay, loam, and sand that underlie the layer of loose sand have apparently never been disturbed.

DIKE-BLANKET PLAN ADOPTED FOR REPAIRS

The problem presented at Zuni was to salvage the present reservoir capacity at permissible cost. Several plans were proposed and discussed. These included extension of the present cutoff wall, construction of a combination earth dike and blanket, and construction of a grout curtain along, and south of, the line of the present cutoff. It was concluded that any of these methods would prove effective, and the dike-blanket plan was finally adopted largely on the basis of comparative costs. As previously mentioned, a similar method had earlier proved effective on the north abutment, which is actually narrower than that on the south.

One of the chief geologic questions involved in this plan had to do with the minimum safe length of the dike. To prevent all chance of leakage, it was obvious that the edge of the lava flow should be protected throughout its extent. This would have called for a dike 500 ft longer than the one shown in Fig. 2. It seemed likely to the geologists, however, that large or destructive leakage would develop only where the lava was underlain by alluvium rather than by bedrock. Such areas as part *BC* of the cross-section shown on the inset diagram of Fig. 2 should be safe even if not protected with a dike. The south end of the dike was finally carried to the natural ground surface well above the high-water line of the reservoir, although its location with reference to the pre-lava valley (point *B*, Fig. 2) was not known and could have been ascertained only by means of a relatively expensive drilling program.

The dike and blanket that were constructed are shown on Fig. 2. In laying the blanket, all holes in the lava were carefully "chinked" with coarse rock. A layer of gravel was then put down, and the 7-ft blanket built up in thin, well-rolled layers of progressively finer material. The toe trench, which was excavated in

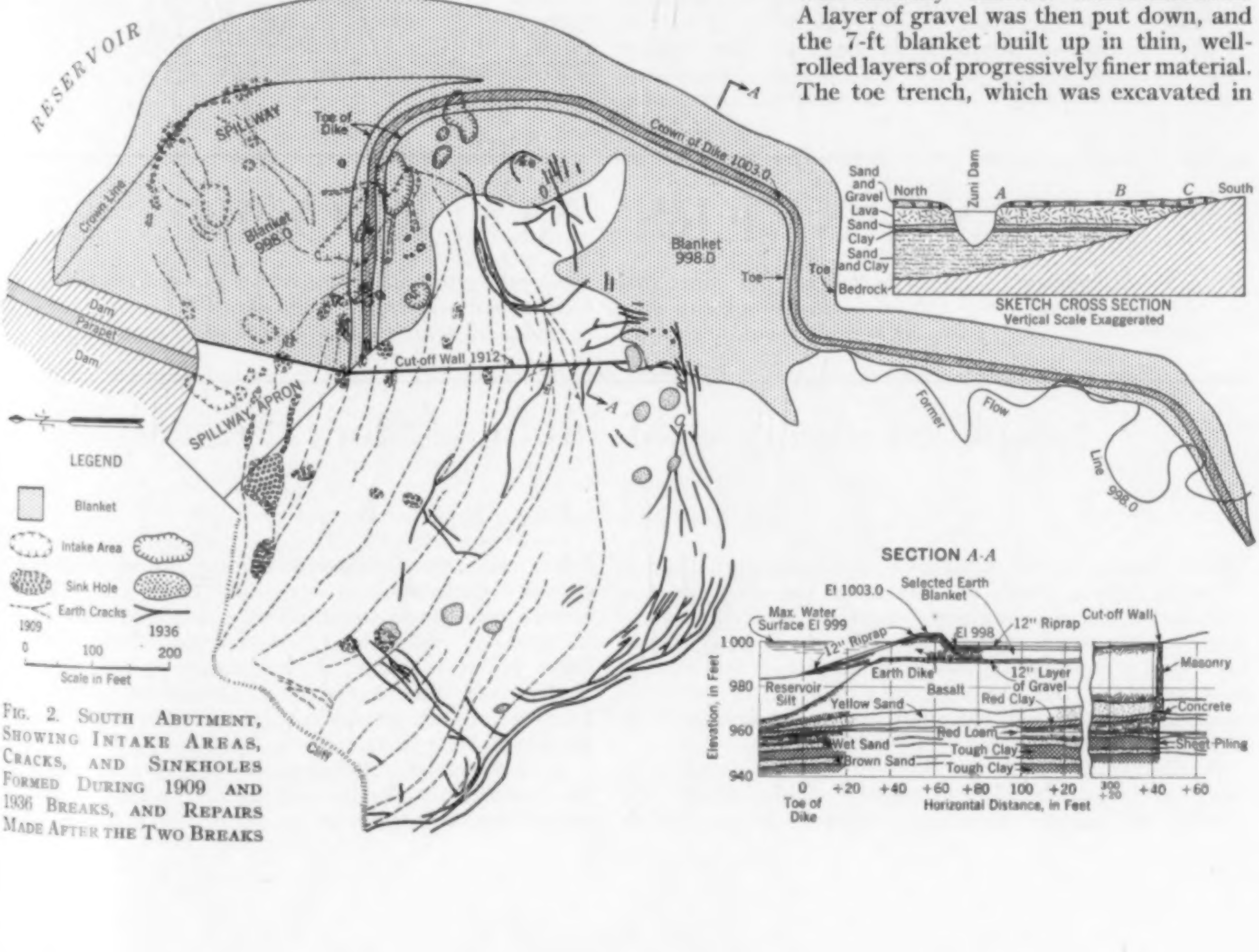

Fig. 2. South Abutment, Showing Intake Areas, Cracks, and Sinkholes Formed During 1909 and 1936 Breaks, and Repairs Made After the Two Breaks

INTAKE AREA DEVELOPED NEAR SPILLWAY IN 1936
Several Similar Openings Were Formed in 1909 and 1936

reservoir silt and tied into the dam, was 15 ft wide and 4 ft deep. The toe slope of the blanket ranges from 3:1 to 10:1.

The dike or levee portion of the structure was built in a similar manner, its slope being 1 on 3. The face of the dike and the blanket toe slope were riprapped with lava rock. Except for a narrow strip along its shoulder, the level portion of the spillway blanket was not riprapped. Most of the earth used was found to contain less than 30 per cent clay, with the remainder fine sand. This material was taken from two borrow pits near the dam, the maximum haul being about one-half mile. Except for two engineers, one foreman, and four shovel operators, all labor was performed by Indians.

Work was begun July 24, 1937, and continued through January 5, 1938, when placing of riprap was suspended to permit the reservoir to fill and to allow complete settlement. In the spring of 1938 water rose to within 12 ft of the spillway level. It did not reach the surface of the blanket, but did provide a good test of the lower parts of the structure. Several minor cracks developed in the fill, probably as a result of settlement of the underlying reservoir silt, but no leaks developed.

Work was resumed April 16 and completed June 30, 1938. Up to July 28, 1939, the water in the reservoir has remained too low to afford a test of the repairs made. Table I shows the costs of the repair project.

At the request of the Office of Indian Affairs, A. C. Spencer and the writer, both of the Geological Survey, were detailed to examine the geologic conditions at the site and to advise on plans for repair of the dam. The engineering phases of the investigation and repairs were carried out under the direction of A. L. Wathen, Director of Irrigation, by T. H. McCarthy, Assoc. M. Am. Soc. C.E., supervising engineer, and by R. H. Rupkey, Assoc. M. Am. Soc. C.E., engineer, of the United Pueblos Agency. J. L. Savage, M. Am. Soc. C.E., F. F. Smith, and C. P. Berkey, M. Am. Soc. C.E., of the U. S. Bureau of Reclamation, examined the dam and reviewed the repair plans.

TABLE I. QUANTITIES AND COSTS

Item	Quantity		Unit Cost	Total Cost
Materials and Labor:				
Earth in levee and blanket	120,275	cu yd	$ 0.226	$27,238.51
Gravel base	1,870	cu yd	1.72	3,217.55
Excavating spillway rock	526	cu yd	4.75	2,499.92
Excavating spillway earth	1,000	cu yd	0.73	730.16
Excavating trench	3,950	cu yd	0.116	460.09
Riprap on face of fill*	15,123	sq yd	0.57	8,638.60
General expense	...		..	6,479.39
Constructing cutoff wall	7.5	cu yd	66.33	497.47
Constructing spillway wall	13	cu yd	10.43	135.64
				$49,897.33
Equipment Charges:				
One-half cost of 4/5-cu yd dragline shovel and trailer				$ 4,223.80
Freight on shovel				575.00
Four 2 1/2-cu yd trucks				5,080.00
One-half cost of compressor				1,825.00
				$11,703.80
Grand total				$61,601.13

* Riprap laid before Jan. 5, 1938 (4,819 sq yd) averages 1 ft in thickness as rock was picked up by hand. The remainder averages about 16 in. in thickness, as rock was blasted out and loaded with power shovel.

ENGINEERS' NOTEBOOK

This department, designed to contain ingenious suggestions and practical data from engineers both young and old, should prove helpful in the solution of many troublesome problems. Reprints of the complete department, 8 1/2 by 11 in., suitable for binding in loose-leaf style, are available each month at 15 cents a copy.

Simplified Analysis of Multiple-Story Frames

By A. FLORIS
LOS ANGELES, CALIF.

THE analysis of multiple-story building frames under lateral forces by means of the moment-distribution method is admittedly tedious and time consuming. However, this is true only if an exaggerated accuracy, usually not necessary in practice, is attempted. In view of the many uncertainties involved in such calculations a speedy and reasonably accurate method is all that is required.

By distributing arbitrary moments to the columns of a story in proportion to the column rigidities and applying the moment-distribution method to the whole frame, there are obtained as many equations as there are stories. Each of these equations, however, contains a limited number of unknowns, depending on the cycles of moment distribution. Restricting the number of these cycles to three, it is obvious that the moment distribution does not extend beyond the third floor joints on either side of the story where the assumed moments are applied.

In a six-story building frame (Fig. 1), for instance, the moment distribution will extend from the first to the second and third; from the second to the first, third,

and fourth; from the third to the second, first, fourth, and fifth stories; and so on.

This being the case, the story equations will be as follows:

$$\left.\begin{array}{ll} N_{11}x + N_{12}y + N_{13}z + N_{14}u & = M_1 \\ N_{21}x + N_{22}y + N_{23}z + N_{24}u + N_{25}v & = M_2 \\ N_{31}x + N_{32}y + N_{33}z + N_{34}u + N_{35}v + N_{36}w & = M_3 \\ N_{41}x + N_{42}y + N_{43}z + N_{44}u + N_{45}v + N_{46}w & = M_4 \\ \qquad N_{52}y + N_{53}z + N_{54}u + N_{55}v + N_{56}w & = M_5 \\ \qquad\qquad N_{63}z + N_{64}u + N_{65}v + N_{66}w & = M_6 \end{array}\right\} \ldots .[1]$$

in which N_{11} represents the sum of the distributed column moments in the first story, when the assumed moments are applied to this story; N_{12}, sum of the distributed column moments in the first story, when the assumed moments are acting in the second story; N_{21}, sum of the distributed column moments in the second story, when the assumed moments are applied to the first story, and so on; and M is the external moment of the particular story indicated by the subscript. (These moments are story shear multiplied by story height.)

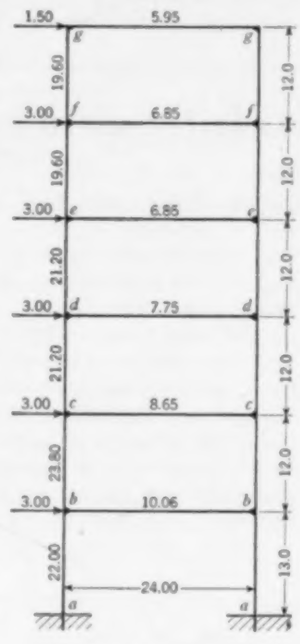

FIG. 1. SIX-STORY RIGID FRAME WITH LATERAL FORCES

It is evident that the first equation represents the equilibrium of the first story; the second, that of the second story, and so on. It is also obvious that the major coefficients N_{11}, N_{22}, N_{33}, . . . , in Eq. 1 are always much greater than the remaining coefficients, since they represent the sum of the column moments in the story where the moment distribution starts. The influence of the other stories upon these columns, expressed by the remaining coefficients, will be always smaller, provided the arbitrary moments applied to the columns of each story do not differ greatly. Consequently, to the solution of these equations the method of iteration can be applied. (See article by the writer entitled "Shear Deformation Included in Three-Moment Equation," CIVIL ENGINEERING for October 1937.)

It should be noted also that the number of terms in the equations of Eq. 1 will never exceed six, no matter how many stories are available. The first and last of these equations will have four terms, the second and next to the last five terms, and the remaining equations six. This is the standard pattern of story equations applicable to all multiple-story frames.

The number of equations obtained in this way can be reduced materially, when it is realized that major damages occurring in multiple-story buildings during earthquakes and hurricanes have been confined principally to the lower stories. It is only for these stories, therefore, that a relatively accurate analysis of the frame is needed; the remaining portion, being less severely stressed, can be analyzed approximately by statics without considering the deformation of the structure.

These considerations suggest that several terms and story equations could be eliminated, without endangering the safety of the structure. Thus if the stresses in the three lower stories are to be determined more accurately than those in the upper stories, Eq. 1 reduces to:

$$\left.\begin{array}{ll} N_{11}x + N_{12}y + N_{13}z + N_{14}u & = M_1 \\ N_{21}x + N_{22}y + N_{23}z + N_{24}u & = M_2 \\ N_{31}x + N_{32}y + N_{33}z + N_{34}u & = M_3 \\ N_{41}x + N_{42}y + N_{43}z + N_{44}u & = M_4 \end{array}\right\} \ldots .[2]$$

regardless of the number of stories above the fourth story in the frame. (As a rule one more equation is needed than the number of stories under investigation.)

By applying both the exact and the approximate equations to a given case, it will be seen that the results obtained by the two methods are practically identical. Thus the use of the reduced equations is justified.

As an example, let us consider the six-story rigid frame shown in Fig. 1. The dimensions, stiffness factors, and lateral forces are shown. Because of symmetry of frame and anti-symmetry of loading, half the frame will be considered in the present analysis. Units used are kips and feet.

By applying an arbitrary moment of 10.0 kip-ft at both ends of the column of a story in succession and distributing these moments to three stories only, above and below this story, there are obtained after three distributions the moments given in Table I. In this table the distributed moments above the fourth floor have been omitted.

Combining the distributed column moments of Table I in accordance with the rule stated above, $N_{11} = 8.36 + 6.19 = 14.55$; $N_{12} = -1.37 - 3.07 = -4.44$; $N_{21} = -3.64 - 1.15 = -4.79$; and so forth. Moreover, $M_1 = \frac{1}{2}(5 \times 3.0 + 1.5)\,13.0 = 107.0$, $M_2 = \frac{1}{2}(4 \times 3.0 + 1.5)\,12.0 = 81.0$ kip-ft, and so forth. Hence Eq. 1 becomes:

$$\begin{array}{rl} 14.55x - 4.44y + 0.97z - 0.18u & = 107.0 \\ -4.79x + 9.91y - 4.24z + 0.86u - 0.21v & = 81.0 \\ 0.94x - 3.76y + 10.17z - 4.07u + 0.89v - 0.20w & = 63.0 \\ -0.18x + 0.75y - 4.04z + 9.67u - 4.26v + 0.72w & = 45.0 \\ -0.17y + 0.82z - 3.95u + 9.78v - 3.48w & = 27.0 \\ -0.18z + 0.66u - 3.50v + 6.80w & = 9.0 \end{array}$$

Solving these equations (in which the plus and minus signs always alternate) by iteration, we obtain after five cycles: $x = 12.85$, $y = 20.90$, $z = 17.75$, $u = 14.35$, $v = 9.25$, and $w = 5.08$. Hence, the actual moments are: $A_b = 8.36 \times 12.85 + 0.43 \times 17.75 - 1.37 \times 20.90 = 86.13$; $B_a = 6.19 \times 12.85 + 0.54 \times 17.75 - 3.07 \times 20.90 - 0.18 \times 14.35 = 22.18$; and so forth. The moments determined in this way are given in the last column of Table I.

TABLE I. SOLUTION BY MEANS OF EQUATION 1

NOTATION	MOMENTS 10.0 KIP-FT APPLIED TO STORY						ACTUAL MOMENTS
	1st	2d	3d	4th	5th	6th	
A_b	+8.36	−1.37	+0.43				+86.13
B_a	+6.19	−3.07	+0.54	−0.18			+22.18
B_b	−2.55	−2.03	+0.45	−0.09			−68.41
B_c	−3.64	+5.10	−0.99	+0.27			+46.38
C_b	−1.15	+4.81	−3.25	+0.59	−0.21		+34.66
C_c	+0.45	−1.92	−1.92	+0.38	−0.08		−63.82
C_d	+0.70	−2.89	+5.17	−0.97	+0.29		+28.78
D_c	+0.24	−0.87	+5.00	−3.10	+0.60	−0.20	+33.97
D_d	−0.06	+0.35	−1.87	−1.80	+0.39	−0.07	−49.21
	$x = 12.85$	$y = 20.90$	$z = 17.75$	$u = 14.35$	$v = 9.25$	$w = 5.08$	

By taking into consideration the three lower stories only—that is, by applying Eq. 2—we obtain:

$$\begin{array}{rl} 14.55x - 4.44y + 0.97z - 0.18u & = 107.0 \\ -4.79x + 9.91y - 4.24z + 0.86u & = 81.0 \\ 0.94x - 3.76y + 10.17z - 4.07u & = 63.0 \\ -0.18x + 0.75y - 4.04z + 9.67u & = 45.0 \end{array}$$

Solving by iteration (five cycles): $x = 12.60$, $y = 20.40$, $z = 16.65$, and $u = 10.24$. Using these values,

the actual moments for the three lower stories are determined, as in the previous case. These moments are given in the last column of Table II.

TABLE II. SOLUTION BY MEANS OF EQUATION 2

Notation	Moments 10.0 Kip-Ft Applied To Story				Actual Moments
	1st	2d	3d	4th	
A_b	+8.36	−1.37	+0.43		+84.70
B_a	+6.19	−3.07	+0.54	−0.18	+22.51
B_b	−2.55	−2.03	+0.45	−0.09	−66.97
B_c	−3.64	+5.10	−0.99	+0.27	+44.66
C_b	−1.15	+4.81	−3.25	+0.59	+35.53
C_c	+0.45	−1.92	−1.92	+0.38	−61.24
C_d	+0.70	−2.89	+5.17	−0.97	+25.39
D_c	+0.24	−0.87	+5.00	−3.10	+36.47
D_d	−0.06	+0.35	−1.87	−1.80	−43.10
	x = 12.60	y = 20.40	z = 16.65	u = 10.24	

In both cases the equilibrium of actual moments around the joints and the equilibrium of moments for each story are satisfied in the present example sufficiently for all practical purposes.

Comparing the actual moments of Table I with those of Table II, it is readily seen that the use of Eq. 2 is fully justified, inasmuch as the differences between the two cases for the most critical stories (the two lower ones) are within the limits of accuracy of such calculations. Consequently, the application of more refined and complicated methods is hardly warranted in practice.

With slight modifications, the method can be applied to any group of stories in the frame. In view of its minor importance in practice, however, this case will not be discussed here in detail.

Driver Vision at Intersections

By Milton Harris, Assoc. M. Am. Soc. C.E.

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VISIBILITY at intersections is undoubtedly a major factor in the safe use of these necessary evils. Much thought has been given to providing safe sight distance at points of intersection and to using warning signs and signals, so that the various units of the traffic stream may commingle or cross without excessive internal friction. One fact, however, still bears investigation and discussion, and that is the angle of approach in relation to the driver's vision from within the machine. Almost all of us at one time or another have realized that it was difficult to see the entire roadway when entering a highway from another at an acute angle to it. To this end, an attempt has been made to analyze the problem and arrive at what should be considered minimum angles of incidence at intersections.

The problem of vision as affected by obstructions outside the roadway has been adequately treated elsewhere. The problem of driver's vision as affected by the vehicle in which he is riding is the subject of this discussion. The angle the vehicle makes to the line of traffic he is about to enter affects the driver's vision, as he obviously does not gaze straight ahead at all times. The corner posts, windshield-dividing strips, and the location and framing of side windows, all affect his vision. The effect of posture, height of eye, location of sea, and other factors are also to be considered. To take one individual car and measure all these factors would be of value in solving our problem, but unfortunately they are variables. However, the majority of passenger and truck vehicles on the road today have certain features of construction in common, and drivers do not vary greatly from a norm. Hence, it is felt that a composite of vehicle and driver would give a relative picture with which to work and one not too far out of line, at least from the standpoint of analysis.

General Motors Corporation, at its proving ground, has made studies of various passenger cars from the standpoint of driver's vision by placing the car in such a position that the center of a semicircular screen coincided with the center of an ordinary driver at usual posture as ascertained from a composite study of drivers. Two lights were placed at average height of eye and $2^1/_2$ in. apart—the normal distance between pupils. The room was darkened, the lights—representing a driver's eyes—were turned on, and the shadows as projected on the screen were sketched on a scaled pad. By using one light at a time the area of partial visibility was ascertained as well as total area of blind spots.

A total of 62 cars built during 1934, 1935, 1936, 1937, and 1938 was thus charted, and from these data a composite chart was calculated, to represent an average car on the road today. This chart, shown in Fig. 1, represents the driver as normally looking straight ahead. The blind area on the right has been taken at 90 deg to the normal, for the reason that in trucks the back frame of the right window is approximately at this angle, while in passenger cars a person riding in the front seat would normally cut the driver's vision at this angle. On the left side, an additional angle of 25 deg was allowed, because of the position of the frame on that side and the angle of peripheral vision that is obtainable by a driver's moving his eyes even slightly to the left.

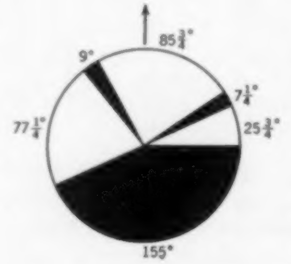

FIG. 1. BLIND AREAS FROM THE DRIVER'S SEAT

It might be argued that a driver would move his head to clear the blind spots caused by roof posts and window frames, but the fact remains that he has a series of blind spots before him even if his eyes are moved, and these blind spots might cover an obstruction that was unnoticed before moving. It is well known that drivers do not glance around fully before entering an intersection, even when there is good visibility that entails but little more than turning the eyes. How important it is then to provide the maximum visibility with the minimum of movement!

With this argument in mind the writer has rotated the composite visibility chart through 160 deg, representing a car approaching an intersection at various angles of incidence ranging from 10 to 90 deg and from both right and left sides. The total angle of available visibility was then plotted against the angle of incidence which the course of a car would make in relation to the course of travel on the approached road (Fig. 2).

Study of this curve reveals that it is of a "left modal" type, indicating more total angular visibility on approaches from the left than on approaches from the right. This fact is borne out by experience, even though the left roof post offers an element of hazard, in that it may hide a pedestrian or vehicle. From 65 to 90 deg on left approach, and from 85 to 90 deg on right approach,

seems to offer the maximum amount of visibility without undue craning of neck or shifting of position.

It is to be noted that from 58 to 65 deg on the left approach the right roof post offers a blind spot; but these

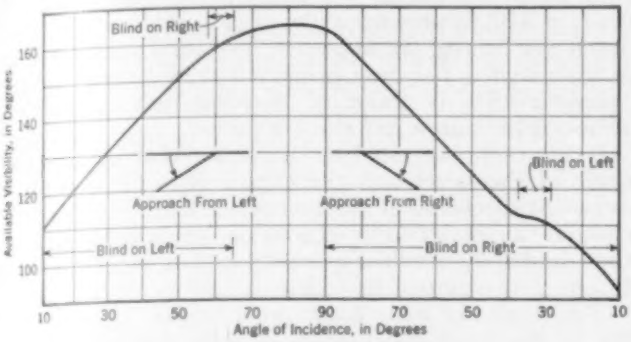

FIG. 2. VISIBILITY AT INTERSECTIONS AS FUNCTION OF ANGLE OF INCIDENCE

angles are subject to variation, depending on the exact position and width of this obstruction. However, at an angle of incidence of 65 deg the blind spot to the rear on the driver's left begins to make itself apparent; hence it is safe to conclude that the angle of incidence on a left approach should not be less than approximately 65 deg.

On a right approach, the blind spot to the rear of the driver on the right side immediately comes into play as the angle of incidence decreases from 90 deg. This checks with driver experience in that it is quite difficult to see traffic approaching from the right when the angle of incidence of right approach is other than 90 deg. A truck driver often has to slide to the right side of the seat in order to glance to the right rear to find if his course is clear, whereas on the left a slight turn of the head or eyes will suffice.

Based on the above reasoning, it is concluded that left approaches should be limited to angles of incidence from 65 to 90 deg and on the right approaches from 85 to 90 deg. These angles are probably subject to variation due to causes stated before, but with whatever tolerance is found to be practicable, the relationship between right and left approaches would remain constant.

Perhaps a discussion of this subject would be incomplete without making some reference to visibility as affected by the relative motion of cars. Consideration of the blind spots caused by roof posts of a car in motion would normally lead one to surmise that any exterior obstructions would soon come into view, even if completely hidden at first. And if the obstruction is a second moving car, it would seem logical to suppose that its driver would see the first car, even if the first driver could not see him (unless both cars were in each other's blind spots and remained there, which is hardly likely because of a normal expectancy of speed differential). But the fact remains that at least two blind spots are before each driver's eyes irrespective of the position of the eyes behind the windshield, not to mention the blind spots to the rear which require a distinct effort to overcome, even with the aid of rearview mirrors.

Another consideration is the fact that a driver must cover at least 180 deg of vision besides giving constant attention to all the other requirements of operating his car. It is easy to forget momentarily what one has seen and to not react to a fleeting impression, thus giving rise to the remark, "I didn't see him." In all probability the driver was right; hence any improvement in design to lessen the demand on a driver's visual exertion would be a step in the right direction.

Discharge of V-Notch Weirs at Low Heads

By FRED W. BLAISDELL, JUN. AM. SOC. C.E.

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IT occasionally becomes necessary to use V-notch weirs at low heads. The usual way of determining discharges at low heads is to calculate the discharge on the basis of one of the published equations or, if the weir has been calibrated at higher heads, to project the calibration curve to the lower heads.

A cursory search of the literature on V-notch weirs has brought to light only two experiments in which the head was permitted to fall below 2 in.: James Barr, in his well-known experiments published under the title, "Experiments Upon the Flow of Water Over Triangular Notches," in *Engineering* (London) for April 8 and 15, 1910, shows a few observations made at heads as low as 0.8 in. (0.067 ft), and Raymond Boucher, Jun. Am. Soc. C.E., in his article, "Nouvelles Expériences sur l'Écoulement en Déversoir Triangulaire" (*Revue Trimestrielle Canadienne*, September 1937), has tabulated experimental data in which the minimum head was 0.049 ft.

In the calibration of several V-notch weirs for use in soil conservation research special attention has recently been given to the discharges at low heads. The results of the calibration of a 90-deg V-notch weir down to a head of 0.0199 ft are presented here to illustrate the errors which result when using V-notch weirs at low heads.

The tests described herein were made as part of the hydraulic research program of the Section of Watershed and Hydrologic Studies, Division of Research, Soil Conservation Service. Through the courtesy of the National Bureau of Standards, the facilities of the National Hydraulic Laboratory were made available to the Soil Conservation Service for the performance of the tests.

The general equation for discharge over V-notch weirs is

$$Q = KH^{5/2} = c_d \frac{8}{15} \tan \frac{\alpha}{2} \sqrt{2g}\, H^{5/2} \ldots\ldots [1]$$

where α is the interior angle of notch. For $\alpha = 90°$ Eq. 1 may be written

$$Q = 4.277\, c_d\, H^{5/2} \ldots\ldots\ldots\ldots\ldots [2]$$

The 90-deg V-notch weir used in the experiments was cut from a sheet of brass $^1/_4$ in. by 15 in. by 24 in. The notch was 9 in. deep. A cross-section through the crest is shown in Fig. 1. The weir had been used for some time, probably about 2 years, and the edges were somewhat worn. Before the experiments began and several times during the course of the experiments the weir plate was cleaned by rubbing it with a mixture of clay and water. The bevel and the downstream face were then rubbed with oil to prevent the nappe from clinging to the weir plate at all heads. In spite of these precautions

the nappe clung to the face of the weir plate at heads of less than 0.19 ft.

The weir was installed in a channel 3 ft wide with the apex of the notch $1^1/_2$ ft above the bottom of the channel. A piezometer connection in the channel wall 4 ft from the weir led to a glass stilling well. The head was measured before and after each test to 0.0005 ft by a point gage. The discharge was measured by determining the weight of water passing over the weir in a measured period of time. Duplicate tests were made if an a priori precision of 0.1 per cent could not readily be attained in all measuring operations.

The results of these tests, as well as those made by Boucher, are shown in Fig. 1. The two curves are close together above a head of 0.3 ft and follow separate courses below 0.3 ft. This seems to indicate that a V-notch weir is not a dependable measuring instrument at heads below 0.3 ft. A simple power equation was fitted to the writer's test results for heads of 0.26 ft or over, the deviation between

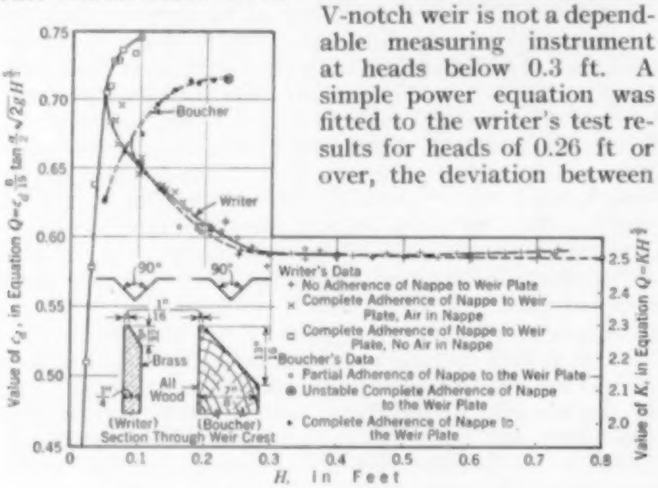

FIG. 1. TESTS ON 90-DEG V-NOTCH WEIRS AT LOW HEADS

the curve and test results being less than 1 per cent. Between heads of 0.05 and 0.10 ft, where two curves exist, it was impossible to make a single curve fit the data with a deviation of less than 12 per cent.

The curves of Fig. 1 show two values of c_d for heads from 0.10 ft to 0.23 ft for Boucher's data and from 0.05 to 0.10 ft for the writer's data. The reasons for this are the same even though the values are different. Boucher's data show that he had complete adherence of the nappe to the weir as the head was increased from 0.049 ft to 0.210 ft, unstable complete adherence for a head of 0.2325 ft, and partial adherence at heads of 0.103 ft and above. It is possible that adherence could have been eliminated at heads of 0.10 ft and above if the weir plate had been oiled. Both curves show that adherence has little effect on c_d when H exceeds 0.30 ft.

The writer obtained complete adherence of the nappe up to heads of 0.186 ft, but two conditions of complete adherence could be obtained from heads of 0.05 ft to 0.10 ft by passing the hand either up or down through the nappe. When the test points fell on the lower curve a ball of air was entrapped in the nappe; for the upper curve there was no air in the nappe. When the ball of air was removed from the nappe, its upper surface was depressed and a higher discharge obtained. At heads below 0.05 ft it was impossible for the ball of air to maintain itself in the nappe. At heads between 0.10 ft and 0.186 ft it was impossible to remove the ball of air from the nappe. Between heads of 0.05 ft and 0.10 ft either condition was attainable at the will of the experimenter. Presumably no air would be in the nappe and the coefficient would follow the upper curve if the head were increased from a value less than 0.05 ft, while a ball of air would be held in the nappe and the coefficient would follow the lower curve if the head were decreased from a value greater than 0.10 ft.

Barr's curves do not, in general, show the same tendency as do the curves presented here. In his Fig. 16 (*ibid.*, p. 470) he presents a plot of c_d vs. H for a 90-deg V-notch weir having the approach floor level with the apex of the notch. The data presented there have the same characteristics as those of Boucher and the writer, although Barr drew in a smooth curve.

It has been suggested to the writer that perhaps the angle of the bevel and the thickness of the weir plate cause the spreading of the curves below 0.3 ft. No conclusions can be drawn as regards this point at the present time, however, since the quantity of data available is insufficient to evaluate this effect.

The results of tests made on a 60-deg V-notch weir led to the same conclusions as were deduced for the 90-deg V-notch weir, and a curve of c_d vs. H drawn from these tests has the same shape as the curves shown in Fig. 1. The available space will not permit the inclusion of more than this statement.

The data presented here indicate that dependable measurements cannot be made with V-notch weirs operating under low heads, unless they are carefully calibrated and the conditions during use duplicate exactly the conditions during calibration. Even then, large errors must be expected. In no case should a weir be used at low heads unless it has been calibrated for such heads. The data presented here should not be used in calculating discharges from other weirs. They are presented only to give a quantitative idea of the errors that might be expected when a weir is used at low heads.

Low heads, for the purpose of the above discussion, may be assumed to have an upper limit of 0.30 ft. The curves shown in Fig. 1 begin to separate at about 0.30 ft, indicating that this value, while it may seem high, is justified.

Copies of the original data used in plotting the curves, together with calibration tables for each of the weirs, have been filed with the Engineering Societies Library, 33 West 39th Street, New York, N.Y.

Talbot's Formula by Slide Rule

By C. B. COE, ASSOC. M. AM. SOC. C.E.

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TALBOT'S formula for culvert openings is in fairly common use in many sections of the country. It is usually solved by a diagram, but may be very quickly computed on any ordinary slide rule. The formula is

$$A = C\sqrt[4]{M^3}$$

in which M = drainage area in acres
A = square feet of opening
C = a coefficient, varying from 0.2 to 1.0

Of course, a log log slide rule will give the value of $M^{0.75}$ in one setting and no further comment need be made here.

For ordinary slide rules, the formula may be written

$$A = C\sqrt{M\sqrt{M}}$$

The procedure for solution is as follows:

1. Find M on the A scale and read $\sqrt{M}$ on the D scale immediately below.

2. Set the index of the slide to this value on the A scale and set the runner to M on the B scale.

3. To the runner set any value of C on the CI scale and under the index, on the D scale, will be found the required value of A.

As in all cases involving the combined use of A and D scales, the decimal point must be carefully watched. Familiarity with the approximate openings required for certain areas will prevent gross errors due to wrong placing of decimal points.

Design for Stadia Board

By John W. Howard, M. Am. Soc. C.E.

Assistant Professor of Civil Engineering, University of Idaho, Moscow, Idaho

The stadia board illustrated herewith was designed primarily for student use, but has proved to be so satisfactory for general topographic purposes that practicing surveyors may find it of value.

As shown in the picture, the foot marks are alternately full and half diamonds, and the intermediate subdivisions are squares. In all cases the vertical dimension of a sloped line is $^1/_{10}$ ft, making interpolation to the nearest 0.01 ft, or at most to 0.02 ft, very easy.

The color combination is a federal yellow background with black markings and is, I believe, the chief virtue of the rod. This color combination retains its individuality regardless of the background—something which cannot be said of the standard black and white, or red, black, and white combination.

The rod is very sturdy also from a structural standpoint, withstanding amateur abuse very successfully. The face is of $^3/_4$-in. spruce, and 4 in. wide. A 3 by $^3/_4$-in. rib of the same material extends along the center of the back (tapering to 1 by $^3/_4$ in. at each end), and is attached to the face by stove bolts and heavy $2^1/_2$-in. wood screws. The ends are shod with $^1/_8$-in. strap iron bent up 6 in. on each side and bolted through the rod. Weight of a 12-ft rod is about 17 lb, and the cost for materials and labor is about $6 when several are made at one time.

Stadia Board

Our Readers Say—

In Comment on Papers, Society Affairs, and Related Professional Interests

Preparing for Future Floods at Rochester, N.Y.

To the Editor: I read the paper by Messrs. Fisher and Covas, in the May issue, with a great deal of interest. It should be pointed out that Mr. Fisher and the late John R. Freeman, Past-President and Honorary Member of the Society, fixed 90,000 cu ft per sec in three days as a reasonable estimate of a future flood through Rochester under present conditions in the Genesee River watershed and stated that the three largest floods during the last 100 years indicate that a much greater flood than any to date may be expected. Since arriving at this figure of 90,000 cu ft per sec, the authors have presented data showing the occurrence of excessive floods in the Merrimac River at Lowell, Mass., and in the Connecticut River at Hartford, Conn., both in 1936, in which 150-year records were exceeded by $66^1/_3$ per cent and 50 per cent, respectively. If we use this factor of $66^1/_2$ per cent with the maximum recorded flood of 54,000 cu ft per sec through Rochester (in 1865), we arrive at a probable future flood of 89,910 cu ft per sec, which is another indication of the reasonableness of the authors' deductions.

The estimate of 90,000 cu ft per sec, however, was based on present conditions in the watershed. Consequently, as the demand in future years arises for flood protection of the fertile fields above Rochester, which are now inundated during moderate floods, and this demand is met by the construction of dikes and retaining walls to prevent such flooding, we can readily appreciate the necessity of planning for reservoirs to replace the natural storage destroyed by upland protection works and of improving the channel capacity through Rochester to provide for a maximum flow of at least 90,000 cu ft per sec as recommended.

Messrs. Fisher and Covas point out the necessity of replacing the Andrews and Main Street bridges with new structures having greater spans, not only to give adequate section for flood flows, but also to eliminate the present hazards of log jams under high-water conditions. The reconstruction of the Andrews Street Bridge will be a relatively simple problem compared with the reconstruction of the Main Street Bridge, due to the fact that privately owned buildings have been constructed over the river north and south of the latter bridge.

Our more recent designs for a new Main Street Bridge, while eliminating two of the existing river piers and widening the channel on the west side, place the new piers in the location of the old ones so as to conform with the property lines for the lots north and south of the bridge. These designs are based on the use of simple spans of built-up steel girders, so that it may be possible to construct the bridge and the new foundations for future buildings over the river in sections—that is, by replacing the present structures gradually over a considerable period of time.

It is very desirable that the city of Rochester have the plans for the reconstruction of the Main Street Bridge and the construction of foundations for future buildings north and south of this bridge well worked out, so that when the occasion arises for quick action on the part of the city, the engineering and legal phases of the matter will have been completely settled.

Henry L. Howe, M. Am. Soc. C.E.
City Engineer of Rochester

Rochester, N.Y.

Gaging Stations for Small Streams

To the Editor: I have read with interest the article entitled "Concrete Controls for Stream Gaging Stations" by O. W. Hartwell in the February issue. This is an excellent type of control for a channel with a uniform cross-section which is protected with a lining for a short distance upstream. Where the profile of the crest across the channel is in the shape of a flat V, as described by Mr. Hartwell, or where it is level but where the height differs from the two heights tested in the laboratory, it is necessary to

construct the rating curve from current meter observations at various flows. An objection to this method of drawing the rating curve is that the peak flow may occur during the night or at some time when it will be impossible to use a current meter. I believe that by widening the crest sufficiently to make a broad crested weir, it would be possible to derive this rating curve by direct computation more accurately than could be done with a current meter, and two or three current meter observations should be sufficient for a check.

The rating curve can be computed by the method and formulas outlined in an article by the writer in collaboration with F. D. Bowlus, M. Am. Soc. C.E., entitled "Adaptation of Venturi Flumes to Flow Measurements" (TRANSACTIONS Am. Soc. C.E., Vol. 101, page 1195). This method assumes that the water flows over some part of the throat or crest at critical depth and that there is little or no loss in energy head between the point of measurement and the crest. The depth, or point on the rating curve, is found by subtracting the velocity head at the point of measurement, plus any friction loss, from the energy head.

Experiments show that the location of the critical depth point is not fixed but tends to move downstream as the depth increases. If the crest is too wide there will be some friction loss between the point of measurement and the critical depth point; and if it is too narrow the latter point will be located over the downstream transition, as shown in Fig. 1, so that the energy head would be

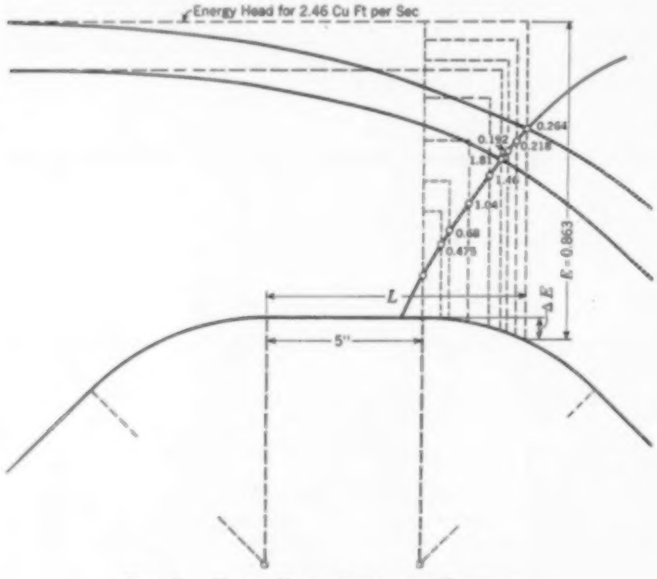

FIG. 1. FLOW OVER TRENTON CONTROL

measured from a point below the crest of the control. The optimum width of the crest had not been determined by previous experiments and since the controls described by Mr. Hartwell were narrow, it was felt that they would help in a solution of the problem.

A detailed analysis of the full-size rating curve, obtained from the National Hydraulic Laboratory, showed that for a given flow the energy head was the same for both heights of weir, the difference between the two curves being merely the difference in velocity heads at the point of measurement. For flows of 0.475 cu ft per sec per ft or less, the rating curves agree with the theory as well as could be expected, but for larger flows there is a difference which can be accounted for by assuming that the critical depth point is located over the lower transition. The locations computed from this discrepancy are shown in Fig. 1. The energy head, E, and the distance of the critical depth point from the end of the upper transition, L, are related by the equation

$$L = 0.72\ E^{0.4}$$

L is probably a function of the flow conditions over the lower rounded section, so it would be safer to use the formula

$$L = \sqrt{E} \text{ or } L = 0.7\sqrt[3]{q}$$

for the minimum width of the crest. Had the 5-in. crest been $11^1/_4$ in. or more, the controls would have followed the theory for all flows up to 2.46 cu ft per sec per ft.

Mr. Hartwell states that the crests of the controls were made in the form of a flat V to measure low flows more accurately. By using a crest wide enough to follow the theory it would be possible to compute the rating curve for a control of any desired profile across the channel and in a channel of any cross-section. This method of computing the rating curves has proved very satisfactory for trapezoidal controls placed in sewer pipes.

The effect of submergence would probably be even less than is shown if the radius of the transition on the downstream side were greater, or if a section with a slope of 1 on 3 or 4 a foot long were interposed between the flat crest and the curve. Such changes on a control 2 ft high with a 1-ft flat crest and a 1.5-ft section on a 1 on 4 slope, followed by 1 on 1, would require 0.08 cu yd more concrete per foot than was used on the actual controls and would give more satisfactory results.

H. K. PALMER, M. Am. Soc. C.E.
Chief Draftsman, Los Angeles County Sanitation Districts
Los Angeles, Calif.

Scale Ratios in Hydraulic Models

DEAR SIR: Reference is made to the article, "Friction in Hydraulic Models," by Thomas DeF. Rogers, in the June issue. Lieutenant Rogers' derivation of equations having to do with flow in smooth channels is interesting, but his application of those equations to the formulating of "model laws" appears to be erroneous.

Flow in open channels usually is influenced chiefly by the force of gravity. Hence, in model analyzing an open-channel problem the experimenter usually designs his model to accord as closely as practicable with the requirements of similitude with respect to the force of gravity. In other words, he seeks to satisfy the requirements of Froude's law (model velocities are to prototype velocities as one is to the square root of the scale ratio of vertical dimensions). In all the models listed in Lieutenant Rogers' Table I, gravity was the predominant force.

Thus, in models such as the ones under discussion, the correct velocity scale ratios are fixed by the immutable action of the force of gravity. That being the case, no significance attaches to "model laws" (such as Lieutenant Rogers' Eq. 3), which purport also to fix the velocity scale ratio.

From the statements just made, it follows that only the last two columns of Table I are of significance. The values in the next-to-last column represent correct scale ratios, while those in the last column show the scale ratios which actually obtained.

These remarks serve to illustrate the fact that correct dynamic scale ratios, model-to-prototype, often are not obtained in practice. This departure from the requirements of dynamic similitude may arise from such situations as the necessity for distorting velocities in order to obtain movement of a model bed (as, for example, models E and F of Table I), or the physical inability to make the wetted surfaces of a highly distorted model rough enough (as, for example, models B and C of Table I). The fact that precise dynamic similitude is not always obtained does not obviate the fact that its attainment is always desirable—and that the failure to obtain it operates to compromise in greater or less degree the reliability of model results.

In Lieutenant Rogers' final paragraph the following thesis is advanced: that Manning's n varies both with absolute roughness and with shape of cross-sections; and that, since the law governing such variation is not known, geometric distortion of models is inadvisable (except in the case of hydraulically-smooth models) "if friction forces are of importance." The reasoning involved in this thesis is not clear. The discussion to this point has had to do with problems in which the force of gravity may be considered predominant. As has been shown, in such cases the correct dynamic scale ratios, model-to-prototype, are fixed, and the experimenter endeavors to satisfy them in so far as is practicable. That he fails to satisfy them is due to causes such as the ones listed in the preceding paragraph—not to lack of ability to evaluate the law governing the variation of Manning's n. All this, of course, presupposes the availability of adequate prototype data. If such data are lacking, the model study should not be attempted.

PAUL W. THOMPSON, Jun. Am. Soc. C.E.
Captain, Corps of Engineers, U. S. Army;
Director, U. S. Waterways Experiment Station
Vicksburg, Miss.

Observations of Standing Waves in Spillway Chutes

To the Editor: In the article on "The Sardis Dam and Reservoir," in the June issue, Mr. Moore mentions the effect of using

Reservoir Inlet Showing Standing Waves in Swiftly Flowing Water, Due to Convergence of Sides of Chute at Its Upper End

converging walls for the chute of the spillway structure. The result, as shown by the hydraulic model study, was the formation of standing waves which extended down the chute into the stilling basin.

This condition is typical for steep chutes with converging walls near the top, as noted by Fred C. Scobey, M. Am. Soc. C.E., in *Technical Bulletin No. 393* of the U. S. Department of Agriculture. Mr. Scobey states on page 90: "The resulting water surface does not take the smooth, glassy characteristics of critical flow, but starts with a series of high, rough waves, capped with white water. Beyond these waves the flow often slashes from side to side, showing little conformity between design and results."

I have observed this condition in actual structures, as illustrated by the accompanying photographs. One of these shows a chute forming the inlet to a reservoir in Nebraska; and the other, the flume chute below the outlet gate of the Guernsey Dam on the North Platte River in Wyoming. In each of those structures, the diamond-shaped waves are very evident, together with the rise of the water surface along the side of the chute, with resulting reduction in its maximum water capacity.

Guernsey Dam, Wyo.—Outlet Chute Below Gate Showing Diamond-Shaped Waves Even with Reduced Flow

H. Alden Foster, M. Am. Soc. C.E.
Parsons, Klapp, Brinckerhoff and Douglas

New York, N.Y.

Idle Funds Should Be Put Into Circulation

To the Editor: I read with much interest Mr. Doherty's article entitled "The Paradox of Social Progress," in the March issue. He mentions the ideal industry as one "operating in a balanced state"—paying out the whole of its income in operating expenses, interest, and dividends. Such a concept applies in fact to the whole of our economy. The basic law of a division-of-labor economy is that a full exchange must be effected for it to function successfully. This means, since labor is first converted into money, or income, that the whole of incomes must be currently paid out for goods and services, and that savings may not exceed in the aggregate the amount used in that manner.

I have just read a new book along this line written by a man of wide experience in industry and government—*Come to Work*, by Victor E. Wilson (House of Field, Inc., New York City). The author establishes the cause of depression in our unused savings. He shows, on the authority of the Brookings Institution, that the savings not expended for goods and services in 1929 were in excess of 10 billion dollars, and lesser amounts annually back to 1923; that the depression would have come earlier but for the expansion of installment sales and bank credit which filled the gap; that the crash came when such expansion ceased; and that the unused savings belonged largely to the recipients of high incomes. Mr. Wilson carries his inquiry back into every depression during the past 100 years, with the same result.

The subtitle of the book is "A Plan for an Economy of Abundance Under the Existing Order," and the plan advocates the spending principle. The main feature is a government guarantee and limitation of profit to monopoly based on the value of the necessary facilities—the guarantee to be the same as the government's credit rating on long-term securities, and the additional profit to be only enough to ensure efficiency and economy in management. Mr. Wilson shows that the guarantee would cost the government nothing except administrative expenses, that it would greatly reduce the incomes—and hence the savings—of the relatively few owners of monopoly, and that it would serve to increase production. Obviously, there could be no objection to running plants to capacity under such an arrangement.

It seems to me that, as matters now stand, we are rapidly nearing another great depression. The excess reserves in the banks and the currency in hoarding—idle savings—are greater than at any time in history—more than 8 billion dollars of the one, based on normal requirements, and between 3 and 4 billion dollars of the other. Because of the limitation set upon our national debt, the government is precluded from much additional borrowing and spending of these idle funds, and Congress has as yet proposed no alternative measures for complying with the law of our economy. The owners of these idle funds failed the country in 1929, and they cannot but fail now if left to their own resources, as advocated by some.

S. D. Clinton, M. Am. Soc. C.E.

Los Angeles, Calif.

Modern Building Codes

To the Editor: The article entitled "A Modern Building Code—Arrangement and Organization," by D. S. Laidlaw in the June issue, has been of interest to me—particularly the suggested subdivision of a typical chapter shown in Table II and Mr. Laidlaw's comment that, "It is possible to make the code almost self-indexing by printing the titles to the subdivisions of the third and lower orders in the outside margins, using separate fonts of type for each order." One of the advantages of the suggested subdivision and the peculiar system of numbering is that revisions of the code may be made in their proper place without disruption of the scheme of arrangement.

Essentially the same arrangement of chapters, articles, sections, and paragraphs with a similar combination of numerals and letters, was used in October 1933 in the first printed draft of the Uniform Building Code—California edition—of which Edwin Bergstrom, architect of Los Angeles, and I were technical editors. This code now termed "Building Code for California" (Edwin Bergstrom, Editor), is available through the California State Chamber of Commerce.

Henry D. Dewell, M. Am. Soc. C.E.
Consulting Engineer

San Francisco, Calif.

The Design of Continuous Frames

DEAR SIR: In the June issue of CIVIL ENGINEERING Dean Grinter presented a method for the automatic design of continuous frames. The usefulness of this method cannot be overestimated and it should receive wide application where economy of design is an important factor. The procedure involves distributing section moduli, as determined from fixed-end moments until a balanced design of the frame results. Although Dean Grinter confined his discussion to structural steel sections, it is interesting to note that the method is directly applicable to members of reinforced concrete in which there is probably a greater field for frame analysis.

Dean Grinter uses the following basic equations in developing his theory:

$$I/c = M/f = S, \text{ and relative } I/L = \frac{S}{L/d}$$

If the section modulus, S, is replaced by bd^2, and the unit stress f, by K, a function of the unit stress of the concrete, the problem may be solved in the same manner as a steel frame. Then for concrete the foregoing equations become

$$bd^2 = M/K, \text{ and relative } I/L = \frac{bd^2}{L/d}$$

The example presented (Fig. 1), taken from Dean Grinter's paper, indicates the simplicity with which a reinforced concrete frame may be solved by automatic design. After computing the

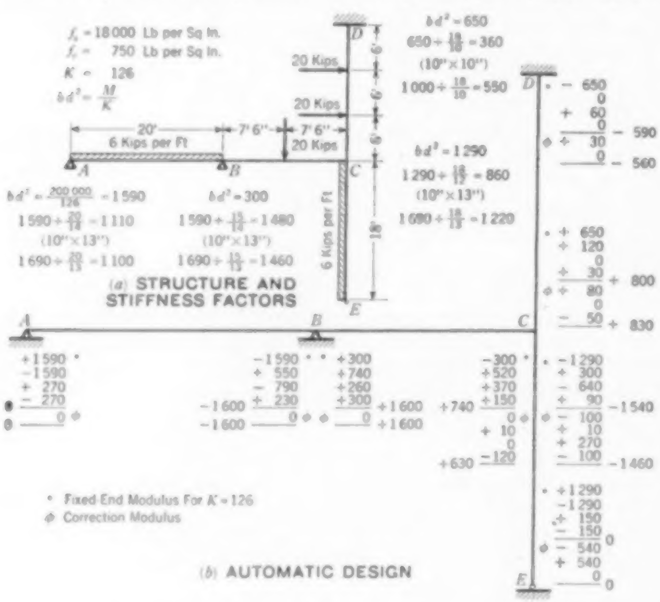

FIG. 1. APPLICATION OF METHOD TO A CONCRETE FRAME

fixed-end moduli, the depth may be so chosen as to give an economical section or, as in this problem, the width may be maintained constant to facilitate construction. After the initial distribution the moduli are revised to a suitable value computed from actual beam dimensions. Direct stress has been neglected but may be included in a manner similar to that of Dean Grinter. After the beam sections have been obtained, reinforcing steel is added to complete a balanced design or the actual moments determined from the section modulus or value of bd^2, and the design of the beam is carried out in any convenient way.

The direction of the loads apparently does not conform with the signs of the fixed-end moduli for the columns of Dean Grinter's problem; I have changed the direction of the loads in this example in order to maintain the same signs.

LESLIE A. IRVIN, Jun. Am. Soc. C.E.
Engineer, T. C. Kistner, Architect
Los Angeles, Calif.

[*Editor's Note:* Regarding the direction of the loads in Fig. 1 of Dean Grinter's article, Dean Grinter writes that a drafting error caused a confusion of signs. Actually the loads on the vertical members (*CD* and *DE*) should have been shown acting toward the right instead of toward the left. Thus Mr. Irvin is correct in making the change, and the loadings in Dean Grinter's Fig. 1 should be revised to conform with the loadings of Fig. 1 in Mr. Irvin's discussion.]

Methods of Foundation Grouting

TO THE EDITOR: Mr. Hays' paper, in the May issue, treats of the methods used in foundation grouting in the authoritative way possible only to one who has had much experience and knows whereof he speaks. It is often thought that grouting consists simply of filling an opening in a rock with a mixture of cement and water, so that the cement will ultimately set and the crack be filled. If this were the case, the thin mixtures used in grouting would never produce a watertight job. Diamond-drill cores taken from pressure-grouted areas show that the seams are filled with a hard dense mass of cement that bonds the fragments of rock solidly together. This result can be accomplished only because the cement particles adhere to the surface of the opening and are filtered out of the grout mixture. Ultimately the opening is completely filled by cement from which the water has been squeezed. The higher the final grouting pressure, the denser and more impervious this filling will be.

The greater the differential pressure acting on a dam foundation, the greater the leakage and the more damage it is likely to do. A high dam will thus require more extensive foundation grouting than would a low dam on the same site. Small cracks, which would not pass an appreciable quantity of water under a low head, must be filled if the foundation is to be made impervious under a high head. Since water will flow through an opening of given size under less head than is required to force grout through the same opening, grouting pressures must in all cases be higher than the differential water pressure to be resisted. A grouting pressure approximately three times the water pressure is required to assure a watertight foundation, and much higher pressure is sometimes used to spread the grout from a single hole over a wider area and thus reduce the cost of drilling.

Washing an area which is to be grouted has always seemed to me of doubtful value. The flow of washing water will follow only the largest opening connecting two or more holes and will not remove any clay or other loose material filling the finer seams. Any material filling an opening in the rock so tightly that it cannot be displaced by continued application of grouting pressure does not need to be removed. Washing undoubtedly adds to the difficulty and expense of grouting a foundation, without increasing its watertightness or otherwise improving it. These comments, however, do not apply to consolidation grouting, which is done to increase the strength of the foundation, limit its deformation under load, or otherwise increase its load-carrying ability. If this type of grouting is to be effective, all the clay must be removed from the horizontal seams in the rock and the space filled with solid cement. This is difficult to accomplish without using a large volume of washing water under a pressure so high that there is danger of displacing the foundation rock. If there are numerous horizontal seams of appreciable thickness, a little calculation will show that an enormous quantity of grout will be required to accomplish the desired results. I believe that consolidation grouting is seldom effective. If the foundation is so bad that consolidation grouting is actually required to support the loads imposed on it by the dam adopted, a better solution of the problem would be to select a type of dam for which the foundation is adequate.

Grouting the foundation of a dam to secure an impervious curtain extending down to tight rock or to a depth sufficient to limit the flow by length of the percolation path is essential to the continued safety of a dam. I do not believe that grouting should be used as a substitute for skill and good judgment of the designer.

Grouting is the only feasible method so far developed for correcting the defects which exist in all dam sites, and is absolutely essential to the safety of all large dams and all dams of any size built on other than good foundations. It is an art rather than a science. Mr. Hay is not only a eminent practitioner of this art but has been responsible for much of its development. His paper should result in better and less costly dams; it will be particularly helpful to construction engineers who, of necessity, must practice this art wherever a dam is built.

J. P. GROWDON, M. Am. Soc. C.E.
Chief Hydraulic Engineer, Aluminum Company of America
Pittsburgh, Pa.

Shortening the Mississippi

To the Editor: Certain aspects of the flood control problem on the lower Mississippi River, described by General Ferguson in the June issue, merit special attention. First, the problem there, from the physical as well as the economic viewpoint, is in a class by itself, and affords no criteria that are readily applicable elsewhere. Second, the use of cutoffs coupled with corrective dredging between cutoffs is without precedent.

This system not merely shortens the river for navigation and expedites the discharge of flood waters into the Gulf of Mexico, but accomplishes three things which hitherto have received little consideration on the part of hydraulicians:

1. It increases discharge capacity while, at the same time, lowering flood stages. This is the opposite effect from that produced by levees which, by confining flood flow, elevate flood stages.
2. It shortens the river without disturbing its characteristic slopes.
3. It shortens the river without producing a straight channel alinement.

None of these accomplishments could have been attained without the dredging operations that were carried on in the reaches between the cutoffs. These were designed to assist the river in scouring its bed over much greater distances above each cutoff than would ordinarily have resulted had the river been left to work out its own destiny. In this respect the effect obtained from the cutoffs is entirely different from the effect of natural cutoffs.

Generally speaking, although natural cutoffs did shorten the river appreciably by eliminating great loops, they accomplished little or nothing towards increasing the flood-carrying capacity of the river. This is because the scouring energy created by a cutoff does most of its work locally and tends to become dissipated farther upstream unless properly conserved. Formerly the means for doing this work were not available, and the technique involved was not understood. Neither were other aspects of cutoffs understood. There was the popular fear that, below a cutoff, elevation of the water surface and shoaling of the river would necessarily result. The cutoff operations as conducted by General Ferguson have shown these downstream effects to be either negligible or absent. Where there was a tendency towards shoaling, the situation was readily taken care of by corrective dredging.

Several natural agencies have operated in the past to maintain the overall length of the Mississippi fairly constant by compensating excessive channel lengthening. These agencies are: (1) cutoffs; (2) the development of chutes; and (3) the flattening of bends. The second of these three has come into operation most often.

The word "chute" is a localism denoting small channels which form across convex bends, or points, usually through scour produced during high-water periods. Some chutes have maintained themselves over long periods without appreciable change; others have enlarged and ultimately become the main river channel. The shortening effected by chutes is not as pronounced as that caused by cutoffs, but the frequency of such chute enlargements causes shortenings to mount into considerable mileage.

Unlike a cutoff across a neck, which invariably causes a lowering of the water surface above the neck, the effect of a chute enlargement at first is to increase the elevation of the water surface above it. Only in time, as the chute gradually assumes the full size of the river, does the water surface drop back to normal.

The channel improvement work at Racetrack Chute illustrates how well-directed corrective dredging operations, coupled with the use of temporary sand dikes, can be employed to accelerate nature's processes. Normally, it takes from 20 to 50 years for a chute to grow into a full-sized river channel. Racetrack Chute first began to develop in 1909 and by 1929 was carrying about half the flow. Diamond Cutoff, undertaken in 1933, a short distance below Racetrack Chute, together with corrective dredging and sand dikes, caused the chute to enlarge rapidly so that in three years it was able to carry two-thirds of the flow. Today it takes the entire flow except at very high stages, when some water still follows the old bend channel.

River shortening by flattening of curvature has been an important factor in the past and operates today. Since the inauguration of General Ferguson's program, shortening by such action has automatically contributed 3.8 miles to the total of 136 miles of shortening accounted for between Angola and Arkansas City (the 370-mile reach in which cutoff operations have been prosecuted).

Gerard H. Matthes, M. Am. Soc. C.E.
Principal Engineer, Mississippi River Commission

Vicksburg, Miss.

Technical Studies of Web Reinforcement Available

To the Editor: The paper, "Welded Shear Reinforcing for Concrete Beams," by Dewey M. McCain in the July issue, is incomplete, even as a description of preliminary tests, unless reference is made to the more outstanding investigations and studies of web reinforcement available in the technical literature of this country. The following list should aid in supplying this evident need.

1. "Proof and Tests of Web Reinforcement Formulas," W. A. Slater, A. R. Lord, and R. R. Zipprodt, Technologic Papers of the Bureau of Standards, Vol. 20, p. 387, Paper No. 314, 1925–1926.
2. "An Investigation of Web Stresses in Reinforced Concrete Beams—Restrained Beams," F. E. Richart and L. J. Larson, *Bulletin No. 175, University of Illinois Engineering Experiment Station*, April 1928.
3. "An Investigation of Web Stresses in Reinforced Concrete Beams," F. E. Richart, *Bulletin No. 166, University of Illinois Engineering Experiment Station*, June 1927.
4. "Design of Large Beams Using Reinforcing Following Stress Trajectories," Charles A. Gilchrist, *Engineering News*, 1914, Vol. 71, No. 10, p. 547, March 12; No. 11, p. 623, March 19; and No. 12, p. 659, March 26.
5. "Studies of Shear in Reinforced Concrete Beams," T. D. Mylrea, Transactions Am. Soc. C.E., Vol. 94, p. 734, 1930.
6. "Tests of Reinforced Concrete T-Beams," T. D. Mylrea, *American Concrete Institute Journal, Proceedings*, Vol. 30, p. 448, 1934.

A study of these publications will reveal that the structural efficiency of the welded units used by Professor McCain has been over-emphasized in comparison with the customary tied construction. The paper would not have given the impression that the differences in strain found in the two types of reinforcement were due to welding of the diagonal bars if the author had tested companion beams with properly tied or clipped diagonal bars. An additional set of companion beams with welded vertical stirrups is also essential for thorough isolation of the effect of welding from that of wiring. Tests in the past have consistently shown little difference between welding and tying if adequate anchorage of all reinforcement exists. Furthermore, although tests of diagonal web reinforcement usually have shown strains at earlier loads than for vertical stirrups, the two types of web reinforcement are ultimately equivalent pound for pound (references 1 and 3).

Certainly, there should be no concern on the part of engineers with regard to the continuity of any properly designed reinforced concrete structure if the reinforcing steel is adequately tied and anchored.

It has been known for many years that welded units will offer advantages, under certain conditions, over tied or clipped reinforcement. The primary advantages, however, do not accrue from structural effectiveness but rather from construction efficiency as follows: (1) Relative position of reinforcing steel is assured since less dependence need be placed upon the "human element" of both worker and inspector; (2) there is economy of time involved in the field operations of placing the beam steel.

A marked disadvantage is the entire loss of local continuity when poor welding exists and breakage of welds due to handling or rodding therefore occurs.

In many cases, the advantages will be sufficient to justify the use of welded reinforcement units, although the unit cost in the past has not favored it for most localities.

George C. Ernst, Assoc. M. Am. Soc. C.E.
Assistant Professor of Civil Engineering, University of Maryland

College Park, Md.

Condensed Program

British American Engineering Congress

NEW YORK, N.Y., SEPTEMBER 5–8, 1939

	AMERICAN SOCIETY OF CIVIL ENGINEERS INSTITUTION OF CIVIL ENGINEERS ENGINEERING INSTITUTE OF CANADA	AMERICAN SOCIETY OF MECHANICAL ENGINEERS INSTITUTION OF MECHANICAL ENGINEERS	LADIES ALL GROUPS
Time	Headquarters: Columbia Univ.	Headquarters: Eng. Soc. Bldg.	
Tuesday Sept. 5, 1939 Morning	General Meeting on Professional Status of the Civil Engineer	Railroad session	Visit to American Museum of Natural History
Afternoon	Boat Excursion about New York harbor, thence to World's Fair by boat. Luncheon and tea aboard boat.		With men on boat excursion and at World's Fair
Evening	At World's Fair		With men at World's Fair
Wednesday Sept. 6, 1939 Morning	Sessions on: (1) Construction Methods (2) Sanitation and Water Supply (3) Highways	Railroad session	(1) Visit to Corning Glass Display, Shopping Tour, Luncheon at Women's Republican Club (2) Shopping Tour, Visit to Morgan Library, Luncheon at Engineering Woman's Club (3) Visit to World's Fair, Luncheon at World's Fair
Luncheon	At Restaurants, Hotels or Lunch Rooms near Columbia University	Pennsylvania Hotel	
Afternoon	Sessions on: (1) Soil Mechanics (2) Landing Fields (3) City Planning and Parkways	Railroad exhibits at World's Fair	Tea at Columbia University Tea at Pennsylvania Hotel
Evening	Banquet and Dance, Hotel Waldorf-Astoria		At Waldorf-Astoria
Thursday Sept. 7, 1939 Morning	Sessions on: (1) Soil Mechanics (2) Structural Design (3) Use of Electricity	Highway Transport session	All-day sightseeing trip, including visit to West Point
Luncheon	At Restaurants, Hotels or Lunchrooms near Columbia University	Pennsylvania Hotel	Luncheon at Bear Mountain Inn
Afternoon	Inspection Trips	Motor exhibits at World's Fair Transatlantic airplane session	Tea at Stevens Institute, Hoboken
Evening	Entertainment at McMillin Theatre, Columbia University		With men at Columbia University
Friday Sept. 8, 1939 9:00 a.m.		Visit to North Beach Airport at World's Fair	
11:00 a.m.	Closing session at World's Fair		With men at closing session
Luncheon	At World's Fair, or as desired	At World's Fair, or as desired	With men of their party
Afternoon	At World's Fair		With men of their party
	Departure of British Civil Engineering Group for Washington, D.C.		
Saturday Sept. 9, 1939		Departure of British Mechanical Group for Schenectady, N.Y.	

British American Engineering Congress

New York, N.Y., September 5–8, 1939

Participating Societies

American Society of Civil Engineers

American Society of Mechanical Engineers

Institution of Civil Engineers

Institution of Mechanical Engineers

Engineering Institute of Canada

Headquarters

Headquarters for sessions of American Society of Civil Engineers, Institution of Civil Engineers, and Engineering Institute of Canada will be Columbia University. Headquarters for the sessions of American Society of Mechanical Engineers and Institution of Mechanical Engineers will be Engineering Societies Building. Social functions and excursions are joint activities of the participating societies.

See Page 23 of Advertising for Reservation and Ticket Order Form.

All events of the Congress are scheduled on Eastern Daylight Saving Time, which is one hour earlier than Eastern Standard Time.

General Meeting

TUESDAY—September 5, 1939

Morning

9:00 **Registration—Low Memorial Library, Columbia University**

10:00 **General Meeting—McMillin Theatre, Columbia University**

Presiding, D. H. SAWYER, *President American Society of Civil Engineers*

"The Professional Status of the Civil Engineer"

INSTITUTION OF CIVIL ENGINEERS

SIR CLEMENT D. M. HINDLEY, *K.C.I.E., M.A., Senior Vice-President, Institution of Civil Engineers.*

ENGINEERING INSTITUTE OF CANADA

C. R. YOUNG, *M. Am. Soc. C.E., M.E.I.C., Professor of Civil Engineering, University of Toronto*, and ROBERT F. LEGGET, *Assoc. M. Am. Soc. C.E., A.M.E.I.C., Assistant Professor of Civil Engineering, University of Toronto.*

AMERICAN SOCIETY OF CIVIL ENGINEERS

ENOCH R. NEEDLES, *M. Am. Soc. C.E., Member of the Board of Direction, Am. Soc. C.E., Chairman, Committee on Professional Objectives; Consulting Engineer*, New York, N.Y.

11:00 **Discussion**

Afternoon

1:00 **Boat excursion including trip up the Hudson River to Palisades, returning along New Jersey shore line, thence up East River to Whitestone Landing for transfer to the World's Fair**—Luncheon and Tea aboard Boat.

Members of A.S.M.E. and Inst. M.E. will go aboard the boat at the Hudson River Day Line Pier, at West 42d Street, at 12:30 p.m.

Ladies in the group visiting the American Museum of Natural History will be taken to West 42d Street to go aboard at 12:30 p.m.

At the close of the sessions at Columbia University, members will be taken to the Hudson River Day Line Pier at West 125th Street to go aboard the boat at 1:00 p.m.

Buffet luncheon will be served at 1:00 p.m.

Departing from 125th Street, the boat will proceed up the Hudson River about a mile beyond the George Washington Bridge, thus affording a view of the Palisades and a passing inspection of the bridge. Turning south, the excursion will follow the New Jersey coast to Staten Island, thence along the pier line of Staten Island past The Narrows, thence northward, following the Brooklyn shore line up the East River to Whitestone Landing.

Tea will be served aboard the boat, after which the party will disembark for transfer by motor coach to the World's Fair.

Evening

No formal plans have been made for the evening, everyone being free to see those features of the World's Fair in which he is interested.

Consult your World's Fair Guide Book for special events scheduled for the evening.

Dinner—Arrangements will be made for members, ladies, and guests to dine together. Consult final program for details.

Entertainment for the Ladies

TUESDAY—September 5, 1939—Morning

10:00 **Ladies' visit to the American Museum of Natural History**

Ladies will leave Columbia University at 10:00 a.m. via motor coaches, for a visit to the American Museum of Natural History. At the conclusion of this visit, the ladies join members on the afternoon boat excursion.

Technical Sessions

Columbia University

WEDNESDAY—September 6, 1939

Morning

SESSION I—CONSTRUCTION METHODS AND EQUIPMENT

SCHERMERHORN HALL—10:00 A.M.

Presiding Officer, DANIEL T. WEBSTER, *Chairman, Construction Division, Am. Soc. C.E., Vice-President, Vermilya Brown Company, Inc.*, New York, N.Y.

INSTITUTION OF CIVIL ENGINEERS

W. STOREY WILSON, *M.C., B.Sc., M. Inst. C.E., Engineering Director, Holloway Bros., Ltd.*, London.

ENGINEERING INSTITUTE OF CANADA

J. A. MCCRORY, *Vice-President, E.I.C., Vice-President and Chief Engineer, Shawinigan Engineering Company*, Montreal.

AMERICAN SOCIETY OF CIVIL ENGINEERS

EDWARD P. PALMER, *M. Am. Soc. C.E., Past-President, Associated General Contractors of America; Consulting Engineer*, New York, N.Y.; and HAROLD W. RICHARDSON, *Assoc. M. Am. Soc. C.E., Associate Editor, Engineering News-Record*, New York, N.Y.

SESSION II—MODERN HIGHWAY PRACTICE

HAVEMEYER HALL—10:00 A.M.

Presiding Officer, LESLIE G. HOLLERAN, *Chairman, Highway Division, Am. Soc. C.E., Consulting Engineer*, New York, N.Y.

INSTITUTION OF CIVIL ENGINEERS

J. D. PIDGEON, *Assoc. M. Inst. C.E., Engineering Inspector, Ministry of Transport, Roads Department (Southern Division)*.

ENGINEERING INSTITUTE OF CANADA

R. M. SMITH, *A.M.E.I.C., Deputy-Minister of Highways, Province of Ontario*, Canada.

AMERICAN SOCIETY OF CIVIL ENGINEERS

MURRAY D. VAN WAGONER, *M. Am. Soc. C.E., State Highway Commissioner, State Highway Department*, Lansing, Mich.

SESSION III—MODERN SANITATION AND WATER SUPPLY

McMILLIN THEATRE—10:00 A.M.

Presiding Officer, H. W. STREETER, *Chairman, Sanitary Engineering Division, Am. Soc. C.E., Senior Sanitary Engineer, U. S. Public Health Service*, Cincinnati, Ohio.

INSTITUTION OF CIVIL ENGINEERS

The Water Supply of London—J. R. DAVIDSON, *C.M.G., M.Sc., Member of the Council, Institution of Civil Engineers; Chief Engineer, Metropolitan Water Board*, London.

Notes on Modern Sanitation in England—DAVID M. WATSON, *B.Sc., M. Inst. C.E., Consulting Engineer*, London.

ENGINEERING INSTITUTE OF CANADA

WILLIAM STORRIE, *M.E.I.C., Consulting Engineer*, Toronto, and ALBERT E. BERRY, *M.E.I.C., Director, Sanitary Engineering Division, Department of Health, Province of Ontario*, Toronto.

AMERICAN SOCIETY OF CIVIL ENGINEERS

MALCOLM PIRNIE, *Vice-President, Am. Soc. C.E., Consulting Engineer*, New York, N.Y, and ABEL WOLMAN, *M. Am. Soc. C.E., Professor of Sanitary Engineering, Johns Hopkins University*, Baltimore, Md.

Afternoon

SESSION I—PARKWAYS AND THEIR INFLUENCE ON URBAN DEVELOPMENT

SCHERMERHORN HALL—2:30 P.M.

Presiding Officer, HARLAND BARTHOLOMEW, *Chairman, City Planning Division, Am.Soc.C.E., Consulting Engineer*, St. Louis, Mo.

INSTITUTION OF CIVIL ENGINEERS

City Planning with Special Reference to the Operation of the Ribbon Development Act of 1935—H. J. MANZONI, *M. Inst. C.E., City Engineer*, Birmingham.

ENGINEERING INSTITUTE OF CANADA

Parkways and Urban Development—ARTHUR SURVEYER, *M. Am. Soc. C.E., Past-President, E.I.C., Consulting Engineer*, Montreal, and JACQUES GREBER, *LL.D., B.L.Sc., Professor of the Town Planning Institute of the University of Paris*, and AIME COUSINEAU, *B.A.Sc., B.S., M.E.I.C., Superintendent-Engineer, Division of Sanitation, Department of Health*, City of Montreal.

AMERICAN SOCIETY OF CIVIL ENGINEERS

Control of Borders Along Main Highways—JAY DOWNER, *M. Am. Soc. C.E., Consulting Engineer*, New York, N.Y.

SESSION II—LANDING FIELDS—AIRPORTS

HAVEMEYER HALL—2:30 P.M.

Presiding Officer, H. M. LEWIS, *Member of Board of Direction, Am. Soc. C.E., Consulting Engineer*, New York, N.Y.

INSTITUTION OF CIVIL ENGINEERS

Airports—R. L. NUNN, *D.S.O., M. Inst. C.E., Director of Public Works*, Singapore, S.S.

ENGINEERING INSTITUTE OF CANADA

Airports and Landing Fields—THE HONORABLE C. D. HOWE, *M. Am. Soc. C.E., Hon. M.E.I.C., Minister of Transport*, Ottawa, and P. G. JOHNSON, *Vice-President, Trans-Canada Air Lines*.

AMERICAN SOCIETY OF CIVIL ENGINEERS

Some Economics of Airports—W. WATTERS PAGON, *M. Am. Soc. C.E., Consulting Engineer*, Baltimore, Md.

SESSION III—SOIL MECHANICS AND FOUNDATIONS

McMILLIN THEATRE—2:30 P.M.

Presiding Officer, CARLTON S. PROCTOR, *Chairman, Soil Mechanics and Foundations Division, Am. Soc. C.E., Consulting Engineer*, New York, N.Y.

AMERICAN SOCIETY OF CIVIL ENGINEERS

Foundations for the Huey P. Long Bridge at New Orleans—WILLIAM P. KIMBALL, *Assoc. M. Am. Soc. C.E., Assistant Professor of Civil Engineering, Thayer School of Civil Engineering, Dartmouth College*, Hanover, N.H.

Influence of Soil Mechanics in the Design of Structures for the New York World's Fair, the Whitestone Bridge and Neighboring Improvements—GEORGE L. FREEMAN, *M. Am. Soc. C.E., Consulting Engineer*, New York, N.Y., and HAMILTON GRAY, *Jun. Am. Soc. C.E., Engineer, Moran, Proctor and Freeman*, New York, N.Y.

Soil Mechanics Laboratory Work for the New York World's Fair, the Whitestone Bridge and Neighboring Structures—DONALD M. BURMISTER, *Assoc. M. Am. Soc. C.E., Assistant Professor of Civil Engineering, Columbia University*, New York, N.Y., and HAMILTON GRAY, *Jun. Am. Soc. C.E., Engineer, Moran, Proctor and Freeman*, New York, N.Y.

Entertainment for the Ladies

WEDNESDAY—September 6, 1939—Morning

Ladies will have the choice of a number of events for the morning as follows. Trips A and B will leave Columbia University at 10:00 a.m. via motor coaches. Ladies going on Trip C to the World's Fair will leave Columbia at 10:00 a.m. going via subway to Pennsylvania Station, thence to the World's Fair via the Long Island Railroad.

Trip A—Visit to the Corning Glass Display, followed by a Shopping Tour with luncheon at the Women's National Republican Club

Trip B—Shopping Tour, followed by visit to Morgan Library, with luncheon at the Engineering Women's Club

Trip C—Visit to the World's Fair with luncheon at the "Casino of Nations" Restaurant

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Trip A—**Visit to Corning Glass Display—Tour of the Bonwit Teller Store—Luncheon at Women's National Republican Club**

Ladies will leave Columbia University at 10:00 a.m. in motor coaches going directly to the Corning Glass Display, 718 Fifth Avenue. After viewing the exhibit and the building the group will go to the Bonwit Teller store for a shopping tour, and from there will walk to the Women's National Republican Club (West 51st Street) for luncheon at 12:30 p.m. Following luncheon, ladies will return to Columbia University by motor coach about 3:00 p.m.

Trip B—**Tour of the Lord and Taylor Store—Visit to Morgan Library—Luncheon at the Engineering Women's Club**

Ladies will leave Columbia University at 10:00 a.m. via motor coaches, going directly to the Lord and Taylor store, Fifth Avenue at 39th Street. After a tour of the store the party will walk to the Morgan Library, 29 East 36th Street.

The Morgan Library houses a collection of illuminated and autographed manuscripts, historical letters and documents, books from the 15th to the 18th century, Rembrandt etchings, armorial bindings, etc.

At the close of the visit to the Library the ladies will walk to the Engineering Women's Club, 126 East 35th Street, for Luncheon, after which the group will return to Columbia University by motor coach about 3:00 p.m.

Trip C—Visit to World's Fair

Luncheon on Fair Grounds.

Ladies will leave Columbia University in a group at 10:00 a.m. and travel by subway to Pennsylvania Station, where they will board a Long Island Railroad train for the World's Fair.

On arriving at the Fair, the party will be taken on a guided tour of points of interest to ladies.

Luncheon will be served at the "Casino of Nations" Restaurant at 1:00 p.m.

WEDNESDAY—September 6, 1939—Afternoon

Tea at Faculty Club, Columbia University

Through the courtesy of Columbia University, tea and refreshments will be served to members, ladies, and guests at the Faculty Club from 4:00 to 6:00 p.m.

Banquet and Dance

WEDNESDAY—September 6, 1939—Evening

HOTEL WALDORF-ASTORIA

Committee: J. W. Barker, *Chairman*, E. W. Stearns, G. L. Knight, *Vice-Chairmen*, Theodore Baumeister, Jr., C. W. Bryan, Jr., and F. Hodgkinson

7:00 **Assembly**

7:45 **Dinner**

9:30 **Addresses**

10:30 **Dancing**

All tables have been arranged for seating 10 persons.

The seating list will close at 2:00 p.m., Tuesday, September 5, 1939.

Those purchasing tickets after that hour will be assigned to tables in order of purchase.

Tickets will be on sale at Columbia University until 5:00 p.m., Wednesday, September 6, 1939.

Preferences expressed for table assignments will be followed as closely as possible by the Committee.

Technical Sessions

Columbia University

THURSDAY—September 7, 1939—Morning

SESSION I—SOIL MECHANICS AND FOUNDATIONS

MCMILLIN THEATRE—10:00 A.M.

Presiding Officer, CARLTON S. PROCTOR, *Chairman, Soil Mechanics and Foundations Division, Am. Soc. C.E., Consulting Engineer*, New York, N.Y.

AMERICAN SOCIETY OF CIVIL ENGINEERS

The Design of Building Foundations as Influenced by Developments in Soil Mechanics—ARTHUR CASAGRANDE, *Assoc. M. Am. Soc. C.E., Assistant Professor of Civil Engineering*, and E. R. FADUM, *Jun. Am. Soc. C.E., Instructor in Civil Engineering, Graduate School of Engineering, Harvard University*, Cambridge, Mass.

Settlement Due to Excavation—CHARLES TERZAGHI, *M. Am. Soc. C.E., Visiting Lecturer, Harvard University*, Cambridge, Mass.

SESSION III—ADVANCES IN THE USE OF ELECTRICITY

HAVEMEYER HALL—10:00 A.M.

Presiding Officer, WILLIAM P. CREAGER, *Chairman, Power Division, Am. Soc. C.E., Consulting Engineer*, Buffalo, N.Y.

ENGINEERING INSTITUTE OF CANADA

O. O. LEFEBVRE, *Past-President, E.I.C., M. Am. Soc. C.E., Controller, Provincial Electricity Board of Quebec*, and THOMAS H. HOGG, *M.E.I.C., M. Am. Soc. C.E., Chairman and Chief Engineer, Hydro-Electric Power Commission of Ontario*.

AMERICAN SOCIETY OF CIVIL ENGINEERS

FREDERICK W. DOOLITTLE, *M. Am. Soc. C.E., Director, The North American Company; Consulting Engineer*, Garden City, N.Y.

SESSION II—STRUCTURAL DESIGN

SCHERMERHORN HALL—10:00 A.M.

Presiding Officer, W. M. WILSON, *Chairman, Structural Division, Am. Soc. C.E., Research Professor, Structural Engineering, University of Illinois*, Urbana, Ill.

INSTITUTION OF CIVIL ENGINEERS

The Crippling Load of a Compression Member in a Framework with Stiff Joints—C. E. INGLIS, *O.B.E., M.A., LL.D., F.R.S., Vice-President, Inst. C.E., Professor of Engineering, Cambridge University*.

AMERICAN SOCIETY OF CIVIL ENGINEERS

Trends in Structural Design in the United States—O. H. AMMANN, *M. Am. Soc. C.E., Director of Engineering, The Port of New York Authority, and Chief Engineer, Triborough Bridge Authority*, New York, N.Y.

Wind Pressure on Structures—GEORGE E. HOWE, *M. Am. Soc. C.E., Designing Engineer, American Bridge Company*, New York, N.Y.

Entertainment for the Ladies

THURSDAY—September 7, 1939—All-Day

10:00 All-day trip for ladies—visit to U. S. Military Academy at West Point, luncheon at Bear Mountain Inn, tea at Stevens Institute of Technology

At 10:00 a.m., ladies will leave by motor coach for an all-day sightseeing trip. Leaving Columbia University, the excursion will proceed northward following the Albany Post Road to Bear Mountain, crossing to the west side of the Hudson River over the Bear Mountain Bridge, thence proceeding to West Point.

After visiting the U. S. Military Academy, the party will go to Bear Mountain Inn, on the west side of the Hudson River, for luncheon.

After luncheon, the return trip will follow down the west side of the Hudson River, stopping at the Stevens Institute of Technology, where tea will be served through the courtesy of President and Mrs. Harvey N. Davis. After tea, the excursion will proceed to New York City via the Lincoln Tunnel.

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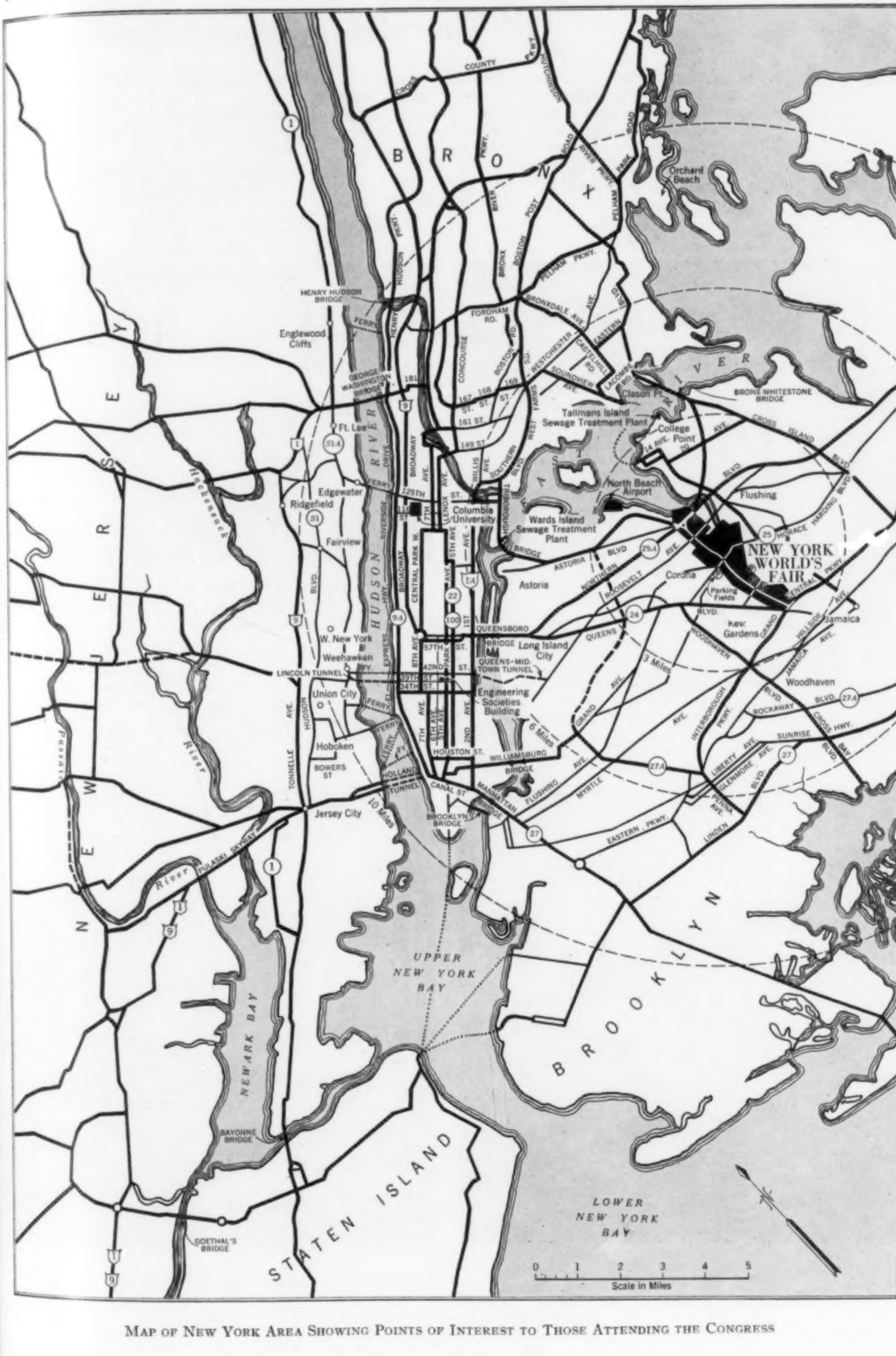
U. S. MILITARY ACADEMY AT WEST POINT

© *Fairchild Aerial Surveys, Inc.*

BEAR MOUNTAIN INN AND BEAR MOUNTAIN BRIDGE



MAP OF NEW YORK AREA SHOWING POINTS OF INTEREST TO THOSE ATTENDING THE CONGRESS

Thursday Afternoon Inspection Trips

Arrangements have been made for inspection visits to the following points of engineering interest. As all these visits start at the same hour and will occupy the afternoon, it will be impossible to participate in more than one. Motor coaches will leave Columbia University at 2:00 p.m.

Trip A—Inspection of Tunnels
Trip B—Inspection of Bridges
Trip C—Inspection of Sanitary Works
Trip D—Inspection of Parkways

Queens Midtown Tunnel Construction

George Washington Bridge

TRIP A—INSPECTION OF TUNNELS

Leaving Columbia University at 2:00 p.m., the excursion will proceed downtown, passing through the Holland Tunnel to New Jersey. Proceeding northward for a view of the Lincoln Tunnel approaches, the excursion will then pass through the Lincoln Tunnel to New York, and will proceed to the Manhattan Field Office of the Queens Midtown Tunnel at the foot of East 42d Street, where an inspection of the work will be made.

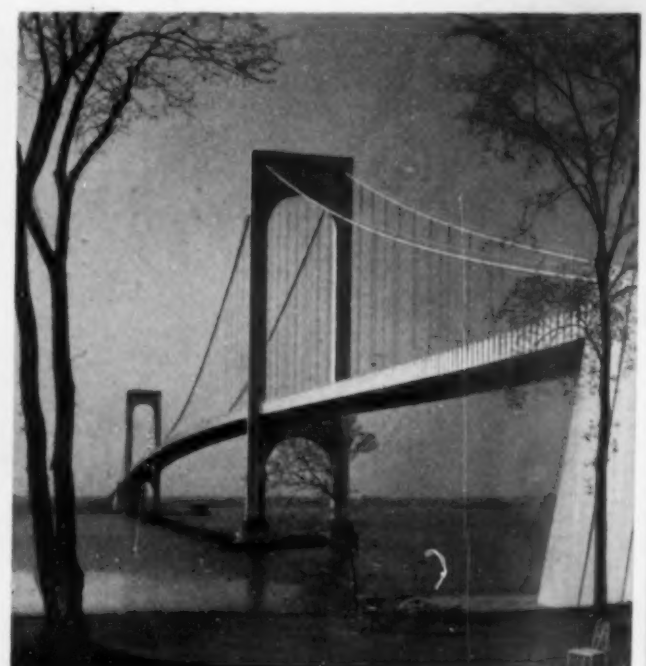
TRIP B—INSPECTION OF BRIDGES

Leaving Columbia University at 2:00 p.m. via motor coach, an itinerary has been arranged to permit crossing of the Triborough Bridge, with view of the Hell Gate Bridge, Bronx-Whitestone Bride, view of Henry Hudson Bridge, George Washington Bridge, and Pulaski Skyway in New Jersey.

Return to Columbia University will be made via the Lincoln Tunnel.

© Wide World Photo

Henry Hudson Bridge



Bronx-Whitestone Bridge

Points of Engineering Interest

TRIP C—INSPECTION OF SANITARY WORKS

The excursion will leave Columbia University at 2:00 p.m. via motor coach, proceeding over the Triborough Bridge to Randalls and Wards Islands for an inspection of the Wards Island Sewage Treatment Works. Following this inspection, the excursion will proceed to the Tallmans Island Sewage Treatment Works at the foot of 127th Street, Flushing, and East River.

The Wards Island Sewage Treatment Works is the largest of the plants in New York City's program of construction of over twenty sewage treatment plants. This plant treats an average flow of about 180 mgd by the activated sludge process and serves a population of about one and a quarter million. It is served by some eleven miles of intercepting sewers and tunnels. Grit chambers are provided in Manhattan and in the Bronx ahead of deep inverted siphons leading to the Island. Excess sludge produced at the plant is shipped to sea in twin-screw Diesel-operated motor vessels carrying about 1,500 tons per trip. The sludge is dumped at sea about eleven miles from the nearest land.

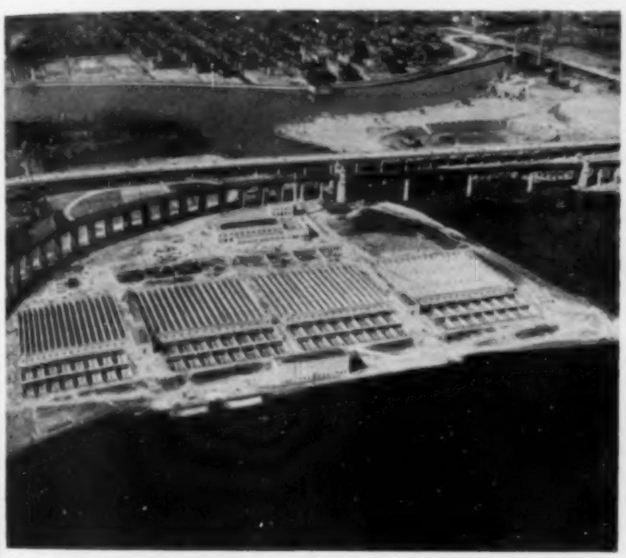
The Tallmans Island Sewage Treatment Works is the third of the modern sewage treatment plants constructed in New York City. It has a capacity of 40 mgd and is designed to serve a population of 300,000. The major elements of the plant include mechanically cleaned grit chambers with grit washing equipment, sludge digestion, primary and final sedimentation, and aeration tanks. The sewage pumps and air compressors are directly connected to gas engines that operate on methane gas produced from digesting sludge. This source of gas may be supplemented by purchased gas. The gas engine installation amounts to 3,500 hp.

TRIP D—INSPECTION OF PARKWAYS

Delegates taking this trip will go by Fifth Avenue buses to the Arsenal at 64th Street and Fifth Avenue, assembling at 2:00 p.m.

As motor coaches are not permitted on the parkways, passenger automobiles will be used.

Leaving the Arsenal, the itinerary calls for travel over the Henry Hudson Parkway, the Saw Mill River Parkways, the Cross County Parkway, and the Cross County and Hutchinson River Parkways. A stop will be made at Pelham Bay Park for a view of the park, Split Rock Golf House, and Orchard Beach. The return trip will cross the Bronx-Whitestone Bridge, the Triborough Bridge, with view of Randalls Island Stadium, and thence to Columbia University.



AIR VIEW—WARDS ISLAND SEWAGE TREATMENT PLANT

SAW MILL RIVER PARKWAY

THURSDAY—September 7, 1939—Evening

9:00 **Meeting in McMillin Academic Theatre, Columbia University, in Celebration of the Seventy-Fifth Anniversary of the Founding of the School of Engineering of Columbia University**

Music—The University Orchestra

Greetings to Guests and Alumni

JOSEPH W. BARKER, *Dean of Engineering*

The Columbia School of Engineering

JAMES K. FINCH, *Renwick Professor of Civil Engineering*

Presentation of Greetings from the Participating Societies

Address—"Government, Economics and the Engineer"

WILLARD T. CHEVALIER, *M. Am. Soc. C.E., Vice-President, McGraw-Hill Publishing Company*

Admission by card only.

Closing Session

FRIDAY—September 8, 1939—Morning

11:00 **Closing and Honors Session**

Hall of Music at the World's Fair.

Presiding, D. H. SAWYER, *President, American Society of Civil Engineers.*

Conferring of Honors

Address—"Have Engineering and Science Gone Too Far?"

CHARLES F. KETTERING, *M.A.S., M.E., President and Director, General Motors Research Corporation,* Detroit, Mich.

Closing Address

ALEXANDER GRAHAM CHRISTIE, *President, American Society of Mechanical Engineers.*

Announcements

All events of the program are scheduled for Eastern Daylight Saving Time, which is one hour earlier than Eastern Standard Time.

Congress Fees

In order to suit the convenience of members attending the meeting, choice of one of the following arrangements may be made:

1. The payment of a $25 Congress Fee provides a delegate, lady, or guest with

(*a*) Room accommodations in Johnson Hall or John Jay Hall, Columbia University, from time of arrival not earlier than Monday, September 4) until departure (not later than Saturday noon, September 9, except through special arrangements). Those who may wish to prolong their stay in New York and continue their room assignments may do so through Columbia University dormitory officials at the Registration Desk.

(*b*) Admission to all events of the Congress from Tuesday, September 5, 1939, through Friday, September 8, 1939. (See Registration Form.)

2. The payment of a $10 Congress Fee provides a delegate, lady, or guest with

(*a*) Room accommodations at Johnson Hall or John Jay Hall, Columbia University, from time of arrival (not earlier than Monday, September 4) until departure (not later than Saturday noon, September 9, except through special arrangements). Those who may wish to prolong their stay in New York and continue their room assignments may do so through Columbia University dormitory officials at the Registration Desk.

(*b*) The privilege of buying individual tickets as desired.

3. Persons who stay at nearby or other hotels will pay such hotel charges direct and have the option of

(*a*) Purchasing admission to all events of the meeting by paying the $25 Congress Fee, or

(*b*) Purchasing individual tickets to events as desired.

Summary of Events and Single Ticket Prices

Tuesday, September 5, 1939

Morning

Ladies' excursion $1.25

Afternoon

Boat trip up Hudson River and about New York Harbor, thence to World's Fair, including luncheon and tea aboard boat, and World's Fair admission . . . $4.25

Wednesday, September 6, 1939

Morning

Ladies' trips, including luncheon (choice of one)

(*a*) Shopping tour, luncheon at Women's National Republican Club $2.25

(*b*) Morgan Library, luncheon at Engineering Women's Club $2.25

(*c*) Visit to World's Fair, including Fair admission, and luncheon at Fair $2.25

Evening

Banquet and dance, Waldorf-Astoria $7.50

Thursday, September 7, 1939

Morning and Afternoon

Ladies' all-day trip, including visit to West Point, luncheon at Bear Mountain Inn, tea at Stevens Institute of Technology $4.50

Afternoon

Inspection trips for men (choice of one)

Trip A, Inspection of tunnels $2.50

Trip B, Inspection of bridges $2.50

Trip C, Inspection of sanitary works $2.50

Trip D, Inspection of parkways (see note re limited attendance) $2.50

Evening

Meeting in commemoration of the 75th anniversary of the founding of the Engineering School, Columbia University . . . . Admission by ticket only

Friday, September 8, 1939

Morning

Honors and closing session, at World's Fair

Transfer to World's Fair by motor coach and World's Fair admission $2.00

Headquarters to Be at Columbia University (116th Street and Broadway)

Believing that the British American Engineering Congress has important educational and technical values, and that the friendly interchange of viewpoint and opinion between English-speaking peoples should be encouraged, Columbia University has offered its facilities in the way of dormitories, lecture halls, Men's and Women's Faculty Clubs, to the attending members and guests of the British American Engineering Congress.

Johnson Hall (116th Street between Amsterdam Avenue and Morningside Drive) and the John Jay Hall (114th Street and Amsterdam Avenue) have been reserved for the accommodation of members, ladies, and guests.

The accommodations consist of single rooms, about $8^1/_2$ by $14^1/_2$ ft in size, furnished with single bed, bureau, wardrobe, and wash basin. Toilet and bath facilities are centrally located on each floor. The facilities on alternate floors will be assigned to men and to ladies.

Laundry Service

For those who reside at Johnson Hall or John Jay Hall, the Student Laundry Service will be available and can furnish 24-hour service if desired.

In general, hotels will be able to furnish 24-hour laundry service.

Key Deposit

Those who stay at Johnson Hall and John Jay Hall will be required by a University regulation to make a $1.00 room key deposit. The $1.00 deposit will be refunded on the return of room key at time of departure.

Hotel Accommodations

For those who prefer accommodations at hotels, a number of nearby hotels of limited capacity will be available. The price range of rooms in these hotels ranges from $2.00 up per day per person for single room. Accommodations at these hotels will be assigned in order of the receipt of requests. Members who stay at hotels will pay the room charges direct.

Hotels

On account of the hotel situation created by the World's Fair attendance, an arrangement is in effect whereby the offices of the American Express Company throughout the country will care for hotel reservations at some 130 New York hotels. Members desiring to stay at hotels may, therefore, make reservations through their local or nearest American Express Company office, or by writing direct to the American Express Company, 65 Broadway, New York, N.Y.

For those who wish to make their own hotel arrangements direct, the following list of hotels with approximate rates is given:

Hotel Rates

Hotels	Without Private Bath		With Private Bath	
	Single Room	Double Room	Single Room	Double Room
Waldorf-Astoria	.....	.....	$7.00 up	$10.00 up
Astor	.....	.....	3.50 up	6.00 up
Biltmore	.....	.....	7.00 up	9.00 up
Chatham	.....	.....	5.00 up	7.00 up
Commodore	.....	.....	4.50 up	6.50 up
Governor Clinton	.....	.....	3.00 up	4.00 up
Lexington	.....	.....	4.00 up	6.00 up
McAlpin	2.50 up	4.00 up	3.00 up	5.00 up
Murray Hill	2.00 up	3.00 up	3.00 up	4.00 up
New Yorker	.....	.....	3.50 up	5.00 up
Pennsylvania	.....	.....	3.50 up	5.00 up
Plaza	.....	.....	6.00 up	8.00 up
Roosevelt	.....	.....	5.00 up	6.00 up
Savoy-Plaza	.....	.....	6.00 up	8.00 up
Vanderbilt	.....	.....	3.50 up	6.00 up

Dining Facilities near Columbia

Ample restaurant facilities will be available near Columbia. Among nearby restaurants are:

Schraffts—108th Street and Broadway
Childs —111th Street and Broadway
Childs —104th Street and Broadway

There are also numerous nearby lunch rooms.

Ladies' Headquarters

The Women's Faculty Club, 410 West 117th Street, New York, N.Y., telephone University 4-3200, Ext. 10 (adjacent to the Men's Faculty Club and Johnson Hall) will be the headquarters for women guests during the meeting.

Ladies are invited to attend all meetings, excursions, and functions.

Climate and Temperature

The average temperatures for New York City in early September are maximum 77 F, minimum 64 F.

The rainfall for the month of September averages 3.5 in.

As the maximum temperature may be higher than the average, as high as 100 F having been experienced, a reasonable supply of summer wear would be desirable in case of unusually warm weather.

Communications

Mail for members attending the meeting should preferably be addressed care of the American Society of Civil Engineers, 33 West 39th Street, New York, N.Y.

Information

The Registration and Information Headquarters will be in the Low Memorial Library. At the Registration Desk a card file of those in attendance and their addresses will be maintained.

Invitation to Juniors and Members of Student Chapters

Juniors and members of Student Chapters are invited to participate in all the events of the Congress.

Travel Facilities to Columbia University

The following methods of reaching Columbia University from railroad stations in New York are given. Persons with heavy or cumbersome baggage should preferably use taxicabs, as no service for assisting with luggage is available on buses or subways.

1. Persons arriving at Pennsylvania Station may use
   - (a) West Side I.R.T. Seventh Avenue Subway (uptown trains, Broadway Line) to 116th Street Station (fare 5 cents)
   - (b) Fifth Avenue buses (fare 10 cents) (No. 4 buses) from Bus Station at 32d Street and Seventh Avenue
   - (c) Taxicab (fare about $1.75)
2. Persons arriving at Grand Central Station may use
   - (a) Fifth Avenue buses (fare 10 cents) (No. 4 or No. 5 buses) from 42d Street and Fifth Avenue, one block west of Grand Central Station
   - (b) Subway, by taking shuttle train from Grand Central Station to Times Square Station, transferring to West Side I.R.T. Seventh Avenue Subway (uptown trains, Broadway Line) to 116th Street Station (fare 5 cents)
   - (c) Taxicab (fare about $1.50)

Committees

Eastern Region Meeting Committee

The program as a whole has been prepared under the direction of the Eastern Region Meeting Committee:

MALCOLM PIRNIE, *Vice-President, Am. Soc. C.E., Chairman*

ARTHUR W. DEAN, H. W. HUDSON, E. R. NEEDLES, A. W. HARRINGTON, H. M. LEWIS, WM. J. SHEA

Directors, Am. Soc. C.E.

J. K. FINCH, WM. J. SHEA

Past-Directors, Am. Soc. C.E.

GEORGE W. BURPEE, *President, Metropolitan Section, Am. Soc. C.E.*

R. E. BAKENHUS, *Past-President, Metropolitan Section, Am. Soc. C.E.*

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Chairman

ROBERT W. SAWYER, 3D

Vice-Chairmen

Columbia University Arrangements, J. K. FINCH
Banquet and Dance, E. W. STEARNS
Hospitality, OLE SINGSTAD
Ladies' Entertainment, CHARLES E. TROUT
Trips and Transportation, GLENN S. REEVES

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Men's Faculty Club—CHARLES F. SWIFT, *Manager*

Dormitories—THOMAS A. MCGOEY, *Director, University Residence Halls;* KATHERINE C. REILEY, *Head of Johnson Hall*

Room Assignments—EDWARD B. FOX, *Assistant Registrar*

Hotel Assignments—ROY C. ZIPPRODT, *Associate Professor of Civil Engineering*

Registration and Information—JEWELL M. GARRELTS, *Associate Professor of Civil Engineering*

Reception and Information—W. J. KREFELD, *Associate Professor of Civil Engineering*

Banquet and Dance

J. W. BARKER, *Chairman*

E. W. STEARNS, *Chairman, Am. Soc. C.E.*

G. L. KNIGHT, *Chairman, A.S.M.E.*

THEODORE BAUMEISTER, JR., R. M. GATES, C. W. BRYAN, JR., F. HODGKINSON

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Ladies' Committee
American Society of Civil Engineers

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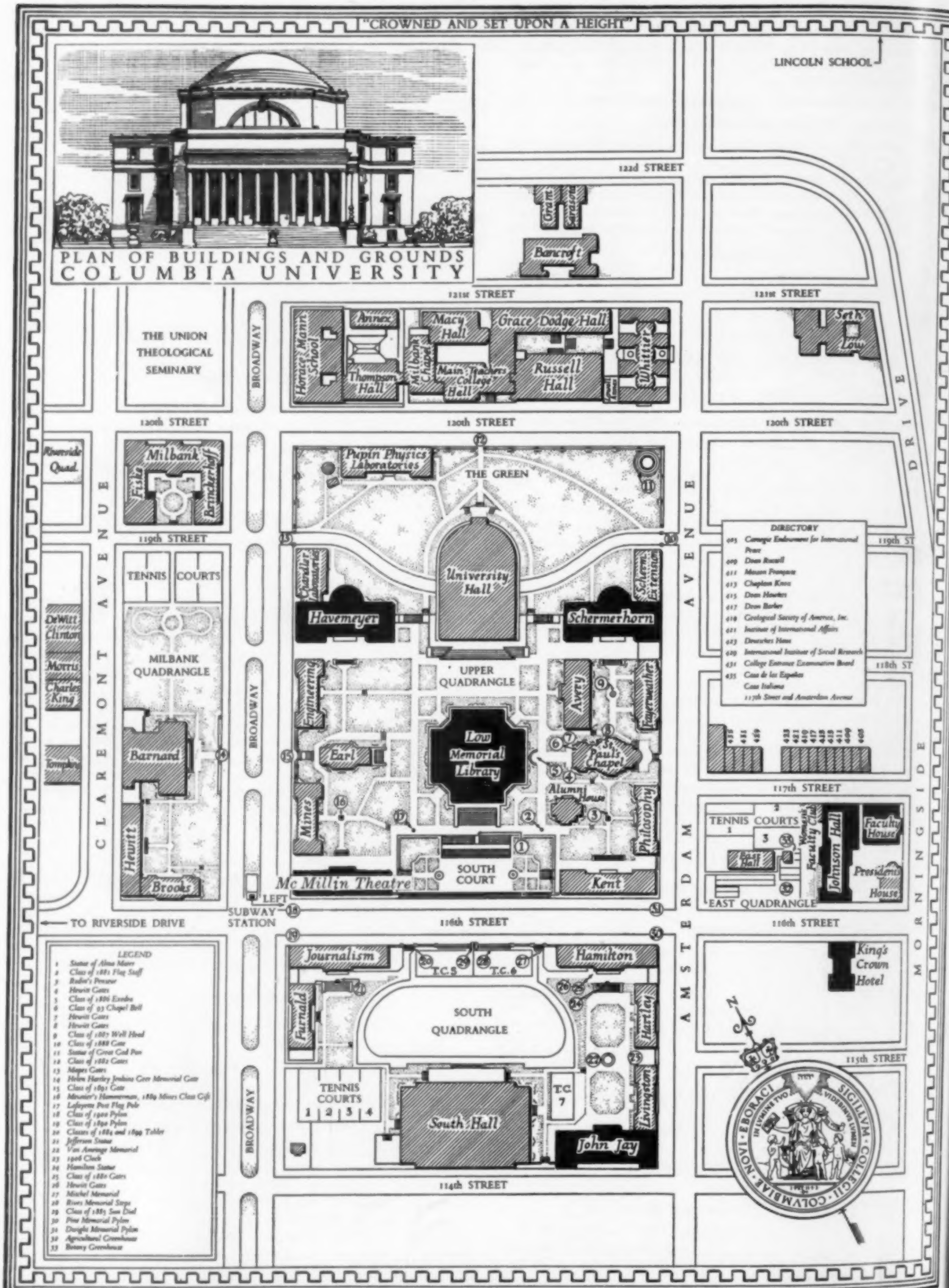

BUILDINGS AND GROUNDS, COLUMBIA UNIVERSITY, SHOWING REGISTRATION HEADQUARTERS AND MEETING PLACES

SOCIETY AFFAIRS

Official and Semi-Official

Glenn L. Parker to Fill Vacancy on Board

GLENN L. PARKER, M. Am. Soc. C.E., was selected by the Board of Direction on July 24, 1939, to fill the vacancy on the Board caused by the death of Ross K. Tiffany, Director from District 12. In accordance with the provisions of the Constitution, Mr. Parker will serve as Director until January 1941, when Mr. Tiffany's term would have expired.

Director Parker is district engineer for the U. S. Geological Survey at Tacoma, Wash., and is now on his thirty-first year of service with that organization. Much of his work since 1919 has had to do with water-supply, storage, and power analyses for the Columbia Basin irrigation and power project. He is a native Westerner—in fact, his birthplace (Butte, Mont.) is in the Society District he now represents. His alma mater is the University of Kansas.

Engineers Club of Western North Carolina Completes First Year

One of the objectives of the Local Sections is "cooperation with other engineering societies, with a view to promoting the general welfare of the Society and the engineering profession." With this in mind, the Tennessee Valley Section has given active support during the past year to the newly formed Engineers Club of Western North Carolina—a composite professional organization which is of special interest in that its area of operations does not center on any large metropolitan city.

EARLY in 1938 a group of engineers in the vicinity of Asheville, N.C. (population 50,000), sensing the need for a professional organization in which all branches of engineering and other allied professions might meet on common ground for the furtherance of the profession as a whole, both economic and social, conceived and organized the Engineers Club of Western North Carolina.

The club was formerly organized on May 16, 1938, with a charter membership of 43. The number has grown steadily until the present rolls include 70 representatives of the various branches of the profession. Many of these men are allied with one or another of the Founder Societies, though such affiliation is not a prerequisite to membership in the group.

During the past year monthly meetings have been held, with diversified programs of interest to all the branches of the profession. Social activities have included a "ladies' night" and a dinner dance.

The Club has a committee working on vocational guidance, and is also sponsoring a series of educational radio programs which are being broadcast locally from Station WWNC. These programs serve to acquaint the public with the membership and the activities of the engineering profession. Publicity through the press has not been neglected and splendid cooperation has been received.

From the financial angle, the club has been very successful. Membership fees in effect are \$5 per member for the first year of membership and \$3 per year thereafter. The present officers of the club are: Paul W. Frisk, president; Joseph Dave, vice-president; M. O. Jensen, secretary; and E. D. Stewart, treasurer. Messrs. Dave and Jensen are members of the Society.

Society Receives \$1,000 Bequest

A BEQUEST of approximately \$1,000 was recently made available to the Society from the estate of the late Karl Emil Hilgard, of Switzerland. Mr. Hilgard, a member of the Society for forty-eight years, died in Zurich on June 21, 1938.

Engineering Foundation is also a beneficiary of Mr. Hilgard, a sum of approximately \$2,000 having been bequeathed it for engineering research work.

Board Commemorates Late Ross K. Tiffany

AT ITS July meeting the Board of Direction unanimously adopted the following resolution commemorating the faithful service of Director Ross K. Tiffany, whose death occurred on June 1, 1939:

WHEREAS the Board of Direction of the American Society of Civil Engineers has been greatly shocked to learn of the death, on June 1, 1939, of its fellow member, Ross K. Tiffany; and

WHEREAS Mr. Tiffany had held many positions of responsibility in which he served his own State of Washington, and the nation at large; and

WHEREAS he has been active in the affairs of the Society since his election, and was at the time of his death a most valued member of the Board of Direction; and

WHEREAS his advice was esteemed in all the councils of the Board and his character endeared him to his fellow members;

Now, therefore, be it resolved, by this Board, assembled in meeting at San Francisco, this day, July 24, 1939, that it places on record its high esteem for Mr. Tiffany, and its sense of loss in his untimely passing; that it extends its sympathy to his family, and directs that this resolution be made a part of its official minutes, and that a copy be forwarded to Mr. Tiffany's family.

District 7 Plans Its Second Summer Gathering at Houghton, Mich.

MEMBERS of District 7 of the Society will hold their second annual summer gathering in Houghton, Mich., August 24–26. Golf and other sports, banquets, discussions of professional problems, fishing excursions, and inspection trips to mines and smelters are all on the program.

District 7 comprises Michigan, Wisconsin, Minnesota, the Dakotas, eastern Montana, and adjacent parts of Canada. Attendance, however, is not limited to members residing in that area. Accommodations of all sorts—hotels, cottages, and cabins—are available at reasonable rates, and reservations can be made by writing the "Am. Soc. C.E. Convention Committee," Michigan College of Mining and Technology, Houghton, Mich.

Annual Convention Under Way

As this issue of CIVIL ENGINEERING goes to press, members from all parts of the country are gathering in San Francisco for the Sixty-Ninth Annual Convention of the Society. Reports just received at Society Headquarters indicate a large registration, including many guests. A complete account of the Convention will be published next month.

First J. Waldo Smith Fellowship Awarded

AWARD of the J. Waldo Smith Fellowship in Hydraulics to Walter J. Meditz and the Polytechnic Institute of Brooklyn was announced by the Board of Direction on July 24, 1939. This fellowship, granted for the year beginning September 1, is the first of its kind, and is financed from the proceeds of funds bequeathed the Society by the late J. Waldo Smith, Hon. M. Am. Soc. C.E. It carries \$1,000, of which \$600 is the stipend of the Fellow, with as much as necessary, up to \$400, to cover the cost of materials and equipment to the laboratory where he is located.

Mr. Meditz is a 1939 graduate of the Brooklyn Polytechnic Institute. The problem assigned him for investigation is "the determination by direct measurement of the differences in the resistance to the flow of water in smooth pipes which are (*a*) horizontal, (*b*) inclined, and (*c*) vertical."

Manual on Land Subdivision

BARRING unforeseen circumstances, the long-sought Manual of Engineering Practice on Land Subdivision will be in the hands of every Society member quite soon. Solely on the basis of "weight of authority," the names of the committee of the City Planning Division responsible for this significant work should be sufficient to guarantee its complete acceptance by the profession.

The committee was not content, however, to advance the composite sum total of its own illustrious experience; and in the "sweatshop" months since 1931, it has assembled and reassembled the manuscript, and reviewed, reread, and rewritten it several times, to incorporate the best views of hundreds of average, better-than-average, and less-than-average practitioners in this important field.

The manual contains 26 illustrations, mostly full-page, to illustrate the five chapters. One chapter outlines the fundamental principles of land subdivision and discusses the separate design factors involved. The economics of land subdivision, with examples of various subdivisions, comprises the burden of Chapter II. Chapters III and IV diagnose and offer cures for abandoned subdivision failures, and finally, Chapter V presents forms for legislation in the interest of public control and regulation.

In the 12 years since the "Code of Practice of the American Society of Civil Engineers" was presented as Manual of Engineering Practice No. 1, a total of 16 Manuals have now been produced by the Society. That they fill an important need is attested by the demand for sale copies despite the fact that from 15,000 to 16,000 copies are normally distributed without charge to members. Formerly the publications of the Society were confined to papers of advanced technical interest, in the forefront of civil engineering knowledge. When the Manuals of Engineering Practice were initiated, the publication program was rounded out by giving an outlet to the practicing members of the Society, where they could classify and assemble, for everyday usefulness, the old and established truths of professional practice, forged and tempered by time.

Manual of Engineering Practice No. 16, on Land Subdivision, is a worthy companion to the preceding fifteen. It "clears the air" of the theoretical opinions and the confusion that is often left in the wake of the more advanced thinkers, and gives practical information for the average everyday practitioner to apply in his work.

Appointments of Society Representatives

W. G. ATWOOD, M. Am. Soc. C.E., has accepted an appointment to represent the Society on the Sectional Committee on Building Code Requirements for Wood of the American Standards Association. R. E. BAKENHUS, M. Am. Soc. C.E., will serve as alternate.

GEORGE E. BEGGS, M. Am. Soc. C.E., has been appointed one of the Society's representatives on the Engineering Foundation for the four-year term, October 1939 to October 1943.

R. W. BERRY, M. Am. Soc. C.E., has been appointed the Society's delegate to the celebration of the fiftieth anniversary of the founding of the Catholic University of America, to be held in Washington, D.C., in November.

ROY W. CARLSON and CLARENCE RAWHOUSER, Associate Members Am. Soc. C.E., have been appointed to represent the Society at the symposium on "Temperature; Its Measurement and Control in Science and Industry" of the American Institute of Physics, to be held in November.

SAMUEL A. GREELEY, M. Am. Soc. C.E., has been reappointed one of the Society's representatives on the Washington Award for the two-year term, August 1939 to August 1941.

JOHN P. HOGAN, M. Am. Soc. C.E., has been reappointed one of the Society's representatives on United Engineering Trustees, Inc., for the four-year term, October 1939 to October 1943.

THOMAS M. JASPER, M. Am. Soc. C.E., was appointed to represent the Society at the meeting of the American Association for the Advancement of Science, held in Milwaukee, Wis., June 19 to 24.

News of Local Sections

Scheduled Meetings

SACRAMENTO SECTION—Regular luncheon meetings at the Elks Club every Tuesday at 12:10 p.m.

SAN FRANCISCO SECTION—Dinner meeting at the Engineers Club on August 15.

Recent Activities

ALABAMA SECTION—*Mobile, June 16:* Joint session with the Engineers Club of Mobile. The program on this occasion consisted of an afternoon inspection trip to view Mobile industries and dock facilities, followed by a short business meeting, dinner, and a technical session. The inspection trip, made under the guidance of J. B. Converse, president of the Engineers Club of Mobile, and Col. Richard Parks, took in petroleum refineries, ore-reduction plants, and the facilities of the Alabama State Docks Board. The feature of the dinner meeting in the evening was a paper on "The Economics of Inland Waterway Transportation," which was presented by A. D. Spottswood, of the U. S. Engineer Office in Mobile. Short talks were also given by Colonel Parks and J. L. Land. *Birmingham, June 26:* This was a special meeting to discuss a recent proposal to transfer some of the counties of the Alabama Section to the Tennessee Valley Section. The Section's annual prize of $15 for the best paper prepared by an engineering student at the University of Alabama was awarded to Charles Davis for his paper on the construction of Oliver Dam at Tuscaloosa.

BUFFALO SECTION—*Buffalo, April 11:* The feature of this luncheon meeting was a talk by Charles Waters, district engineer for the New York State Department of Public Works. Mr. Waters discussed recent devices developed by the department that will aid in safe driving. A general discussion followed this talk. *Niagara Falls, N.Y., May 9:* Following a dinner, Wallace Carr, engineer for the Buffalo, Niagara and Eastern Power Company, spoke on the development of Niagara power, tracing the subject from the earliest settlement of the region through the construction of tunnels for water power. Oliver Dales, another engineer with the company, continued the story through the transmission of electrical current by power lines. Talks were also given by George Bassett, Walter McClough, and Harry L. Noyes, who discussed other phases of the subject of power.

COLORADO SECTION—*Eldorado Springs, June 17:* Following the annual outing for members and their families, a picnic dinner and motion pictures were enjoyed. These films, which depicted interesting activities of the U. S. Navy, were shown by Lt. Commander C. M. Johnson, commanding officer for the Denver district of the Navy. During the meeting a resolution of sympathy on the death of Roy C. Gowdy, member of the Section and former Society officer, was presented.

DULUTH SECTION—*April 17* and *May 15:* A talk on the engineering work of the city health department was the feature of the April luncheon meeting. The principal speaker on this program was R. H. Ruble, research engineer for the Minnesota State Board of Health. The May meeting was given over to discussion of a number of business matters.

GEORGIA SECTION—*Atlanta, June 12:* Despite a heavy downpour many turned out on this occasion for an inspection trip to the Atlanta airport, the fourth largest in the country in point of traffic volume. After a tour of the various places of interest in the field, box luncheons exactly like those given airline passengers were served to everyone. J. H. Gray, city manager of the airport, then gave a talk on the airport, pointing out the need for longer runways and enlarged facilities.

HAWAII SECTION—*Honolulu, May 23:* The guest of honor at this dinner meeting was Lt. Wilfrid J. Holmes, who gave an interesting and instructive talk on Diesel engines. Lieutenant Holmes is a retired naval officer.

ILLINOIS SECTION—*June 16:* Philip C. Rutledge, associate professor of civil engineering at Purdue University, gave an

illustrated talk at this session. His topic was "The Mechanical Characteristics of Soil Analysis."

Indiana Section—*Indianapolis, June 15:* Members of the Section, their families, and guests made an inspection tour of the facilities and plant of the Indianapolis Water Company. The operation of filters was observed, and laboratory control of the daily operations at the plant was explained by the technician in charge. The meeting was arranged by Howard S. Morse, general manager of the company, and C. K. Calvert, chief chemist. A picnic supper concluded the program, Mrs. Calvert acting as hostess.

Kansas City (Mo.) Section—*June 23:* This was the last meeting before the summer recess, and a number of business matters were discussed. The principal speaker of the evening was Col. G. M. Peek, Field Artillery, U. S. Army, who reviewed the present international situation and emphasized the necessity for preparedness on the part of this country.

Kansas State Section—*Topeka, May 12:* The feature of this occasion was the presentation of the Section's awards to the outstanding engineering graduates in the region. Those thus honored were James R. Shipley, of the University of Kansas, and James J. Stout, of Kansas State College. The main speaker of the evening was R. B. Wills, engineer of design for the Kansas State Highway Commission.

Maryland Section—*Baltimore, June 7:* G. J. Requardt reported on the Chattanooga Meeting of the Society, at which he was the official representative of the Section. Mr. Requardt also discussed the difficulty of enforcing the engineers' registration law. Others who spoke on different aspects of the problem were Paul Holland and Edward J. Dougherty, president of the Section. A talk on the recent bill authorizing the comprehensive coordinate system for Maryland concluded the program. This was given by Samuel S. Steinberg, dean of the college of engineering at the University of Maryland.

Miami Section—*January, February, April, May,* and *June:* At the January meeting the guest speaker was Fred Stutz, of the U. S. Public Health Service, who emphasized the care being taken in Florida to control the mosquito. Motion pictures showing the life span of various types of mosquitoes concluded the program. These were shown by Charles Carnahan, associate public health engineer for the U. S. Public Health Service. Guests at the February meeting included Roscoe Young, of the Detroit Section, and a member of the staff of General Motors. The latter spoke, as did Earl M. De Noon, who described the work being accomplished in the local testing laboratory of the General Motors Research Corporation. The April and May meetings were devoted largely to business, the latter session taking place at the time of the annual banquet of the Florida Section of the American Water Works Association. The technical program presented at the June meeting consisted of a talk by Ralph W. Reynolds, superintendent of the West Palm Beach Water Company. Mr. Reynolds discussed the water supply problems of his part of the state and stressed the need for a comprehensive survey of the whole region.

Mid-Missouri Section—*Rolla, April 24:* This session was open to the engineering students of the Missouri School of Mines, and a large number of them attended. A review of the articles in the April issue of Civil Engineering initiated the program. This was given by John A. Short, a Junior in the Section. The principal address of the evening was delivered by Dean Curtis, of the engineering school of the University of Missouri, whose subject was "The TVA Act of 1933 and the Developments Resulting from It." Dean Curtis was formerly chief chemist of the Tennessee Valley Authority. *Lake of the Ozarks, June 3:* The first part of this outing meeting consisted of an inspection trip through the power plant of the Union Electric Light and Power Company, located at the dam across the Osage River forming the Lake of the Ozarks. Two staff members of the company—Wayne S. Frame and Raymond S. Weldy—conducted the group about the plant and explained its operation. Following this tour the members and their guests enjoyed a two-hour boat trip on the lake and a dinner dance. Later in the evening there was a technical program consisting of a paper by Mr. Frame on the subject of the dam development viewed that afternoon.

Northeastern Section—*Durham, N.H., May 12:* Joint dinner meeting with the University of New Hampshire Student Chapter. Brief remarks were made by Arthur W. Dean, Director of the Society, and Samuel M. Ellsworth, president of the Section. Then James K. Finch, Renwick Professor of Civil Engineering at Columbia University, gave an interesting talk on "The Relation of the Practicing Engineer to Engineering Education."

Philadelphia Section—*June 15:* The Sandy Run Country Club near Philadelphia was the scene of the annual meeting of the Section. During the afternoon sports and a golf tournament were enjoyed, and the winners in the athletic contests received prizes during dinner. William E. A. Doherty, retiring president, then introduced the new Section officers who are as follows: Scott B. Lilly, president; Charles A. Howland, vice-president; and Reginald C. Scott, secretary-treasurer. A vote of thanks was given Mr. Doherty for his accomplishments during his term as president, and Professor Lilly then outlined in detail his plans for the coming year. The guests included Sanford Sawin, Director of the Society, and two former Directors—Charles H. Stevens and Henry J. Sherman.

Pittsburgh Section—*May 20:* Joint inspection trip with the Engineers Society of Pennsylvania. This trip, which included visits to Mahoning Dam and to several locks and dams on the Allegheny River, was conceded one of the best trips held in recent years. The entire tour was made possible through the courtesy and efforts of Lt. Col. W. E. R. Covell, district engineer for the U. S. Engineer Office at Pittsburgh.

Sacramento Section—*June 6, 13, 20,* and *27:* At the first of these series of meetings the speaker was Bennett Chapple, vice-president of the American Rolling Mills Company, Middletown, Ohio, who discussed the rôle of iron and steel in modern engineering development. A dinner meeting was held on the 13th in lieu of the regular luncheon. On this occasion S. H. Taylor, West Coast manager of the Lincoln Electric Company, spoke on "All Welded Building Construction," and presented two motion pictures on the subject of welding. On the 20th Fred C. Scobey, senior irrigation engineer for the U. S. Department of Agriculture, gave an illustrated talk on the hydraulic jump, and on the 27th Leonard C. Hollister spoke on "Fundamentals of Modern Bridge Design." Mr. Hollister is designing engineer for the California State Bridge Department. *Junior Forum, June 10* and *14:* The first of these two meetings took the form of a field trip to various projects under construction by the city of Sacramento. At the regular monthly meeting on the 14th D. J. Faustman, member of the Forum, spoke on "Land Transportation of the Future." The new officers for the Forum are J. A. Conwell, president; Edwin Epstein, vice-president; and R. L. Richardson, secretary.

San Diego Section—*June 22:* Joint meeting with the San Diego Alumni Association of the California Institute of Technology. Irving P. Krick, associate professor of meteorology at the Institute, was the speaker on this occasion, his subject being "Three Dimensional Weather Analysis." In connection with his talk Dr. Krick showed some interesting motion pictures.

San Francisco Section—*June:* The subject of the technical talk at the June meeting of the San Francisco Section was "Crude Oil Refining." C. H. Britten, assistant manager of technical application for the Shell Oil Company, presented this complicated subject in a concise manner.

Spokane Section—*June 9:* At this time announcement was made of the Section's annual award of the fee for Junior membership in the Society. This year the awards go to George L. Bodhaine, of Washington State College, and Joseph H. Latimore, of the University of Idaho. It was also announced that H. E. Phelps, president of the Section, will represent the Section at the Annual Convention in San Francisco. The meeting concluded with an interesting demonstration of a hydraulic slide rule, which was shown by R. D. Gladding, originator of the slide rule.

Tacoma Section—*June 13:* A symposium on the Lake Washington Bridge was the feature of this meeting, the speakers being Charles Andrew, consulting engineer for the Washington Toll Bridge Authority, and Frederick Van Antwerp, engineer for the Parker-Schram Company. Mr. Andrew reviewed the general design of the Lake Washington Bridge and showed slides of the early stages of construction, while Mr. Van Antwerp discussed the contractor's construction problems on the project. During the business session a resolution of sympathy on the death of Director Ross K. Tiffany was presented and adopted.

ITEMS OF INTEREST

Engineering Events in Brief

Civil Engineering for September

September's table of contents finds two of this month's authors back in the ranks. Charles E. Wuerpel contributes his second article on concrete "for the benefit of those who are not concrete experts and who have not had an opportunity in recent years to devote themselves to the minutiae of the subject." His specific topic is "Choice of Aggregates and Design of Concrete Mixes." R. T. Colburn follows up his paper on "Construction Plant Planning for Large Dams" with another on cofferdam construction, drawing again for his examples from the experience of the Tennessee Valley Authority.

Also on the schedule are an article by E. N. Noyes on the Corpus Christi sea wall project, one by J. T. Hallett with comprehensive data on traffic accidents in Indiana, and one by M. C. Boyer on stream gaging. From the Annual Convention will come other papers, of which two can be announced as reasonably definite at this time—a historical review of the measures taken to protect Chicago's water supply (S. N. Karrick), and a discussion of the silt problem in the Imperial Valley resulting from the completion of Hoover Dam (M. J. Dowd). Thus a wide variety of subject matter is assured.

A.I.S.C. Bridge Awards

Awards for the four most beautiful steel bridges constructed during 1938 were recently announced by the American Institute of Steel Construction. First place in Class A (bridges costing $1,000,000 and over) went to the Middletown-Portland Bridge at Middletown, Conn. The structure was designed by William G. Grove, M. Am. Soc. C.E., under the direction of L. G. Sumner, M. Am. Soc. C.E., engineer of bridges and structures for the Connecticut State Highway Department.

First place in Class B (bridges costing between $250,000 and $1,000,000) went to the Capital Bridge across Kentucky River at Frankfort, Ky. Engineers were the Bridge Department of the Department of Highways of Kentucky.

In Class C (bridges costing less than $250,000) first place was awarded the bridge over the Middle Fork of Flathead River at Belton, Mont., designed by the Montana Highway Department.

"Most beautiful movable bridge" was the Lafayette Avenue Bridge over the east channel of Saginaw River at Bay City, Mich. The firm of Hazelet and Erdal, of Chicago, were the designers.

Honorable mentions were given in three classes, as follows: Class A, Bluewater Bridge at Port Huron, Mich. (Modjeski, Masters, and Case); Class B, Chain Bridge, over the Potomac near Washington, D.C. (Modjeski, Masters and Case); Class C, Burnham Park Pedestrian Bridge, Chicago (Engineering Division of the Chicago Park District), and the steel arch span of the Thousand Islands International Bridge (Robinson and Steinman).

This is the eleventh consecutive year for these awards. Prize-winning structures are decorated with stainless steel plaques designating them the most beautiful constructed during the year.

Basic Features of Maryland's New Surveying Act

By S. S. Steinberg, M. Am. Soc. C.E

Dean, College of Engineering, University of Maryland, College Park, Md.

Maryland has recently followed the example of New Jersey, Pennsylvania, and New York in legally defining and adopting a state coordinate system. The Maryland act passed at the recent session of the state legislature is said to be the most comprehensive of its kind. It not only embodies the chief recommendations of the Joint Committee on Land Surveys and Titles (of the Society and the American Bar Association) but includes some objectives and functions in connection with surveys and maps not yet undertaken elsewhere.

The Act consists of three major parts which may be summarized as follows:

Maryland Coordinate System. The Act defines and adopts the "Maryland Coordinate System" which must be so designated in any land description in which it is used. The definition of the system is that adopted by the United States Coast and Geodetic Survey and is a Lambert conformal projection of the Clarke spheroid of 1866, having standard parallels at north latitude 38°18′ and 39°27′, along which parallels the scale is exact.

The use of the coordinate system is permissive and not compulsory, as the law provides that "nothing contained in the Act shall be interpreted as requiring any purchaser or mortgagee to rely wholly on a description based upon the Maryland coordinate system." The Act specifically excludes Baltimore since that city has used an excellent coordinate system for many years.

Survey Stations. The Act permits qualified engineers or surveyors, or their assistants, in the execution of surveys, to enter upon private property to use a marked survey station established under the direction of the U. S. Coast and Geodetic Survey, or as a part of the Maryland Coordinate System, or any other organization whose survey stations have been established by or in accordance with the requirements of the Maryland Bureau of Control Surveys and Maps.

The Act provides that no unnecessary damage be done by the surveyor to the property on which a survey station stands; and in case of damage, it provides for reimbursement to the owner.

The Act protects marks and monuments at any survey station established by or under the U. S. Coast and Geodetic Survey, the Maryland Bureau of Control Surveys and Maps, or by any other organization, state, municipal, or private, whose survey stations have been established in accordance with the requirements of that Bureau. A penalty is provided for injuring, defacing, or destroying a survey station, or for offering any obstacles to the proper, reasonable, and legal use of such stations.

Bureau of Control Surveys and Maps. The Act establishes in the Maryland Department of Public Works, a Bureau of Control Surveys and Maps whose function it becomes to administer the laws relating to the Maryland Coordinate System; to extend this system and to take over the duties and extend the activities of the present Maryland Mapping Agency, which has been in operation as a joint project of the University of Maryland, the State Planning Commission, and the Works Progress Administration since the termination of the CWA in March 1934. The control of the Bureau of Control Surveys and Maps will be in an Advisory Board consisting of the chief engineer of the Maryland State Roads Commission, the chairman of the State Planning Commission and the dean of the College of Engineering of the University of Maryland.

The Act also provides that the Bureau shall develop its activities in accordance with the following specific objectives:

"1. To coordinate the efforts of the many agencies, federal, state, city, county, and private, making surveys and maps in Maryland, in order to avoid duplication and overlapping.

"2. To develop permanent records of surveys and maps in the state.

"3. To develop uniform specifications for surveying and mapping.

"4. To collect and preserve all worthwhile survey data, thereby salvaging for future use much valuable information now being lost; and to transcribe information to a master map.

"5. To encourage engineers and surveyors to tie their surveys into the horizontal and vertical control network of the

U. S. Coast and Geodetic Survey, thereby making their lines practically indestructible.

"6. To encourage engineers and surveyors to adopt the use of the single plane coordinate system now being developed in Maryland, for engineering projects, for municipal and county boundaries, and for private property surveys.

"7. To become a depository for file copies of Maryland maps by all agencies and to establish a Library of Maps and Charts of the State.

"8. To serve as an information bureau concerning maps of the State or any portion thereof; to retail standard maps such as are in general demand; and, to a limited extent, reproduce maps for a reasonable charge.

"9. To serve annually as a central meeting point for representatives of Maryland map-making organizations to discuss, coordinate, and plan for mapping of the State; to direct the trend of surveys and maps of the State; and to advocate consolidation of State mapping bureaus to promote efficiency.

"10. To promote the continuation and completion of the local control surveys begun in Maryland under the CWA; to serve as the coordinating agency for any program of mapping launched by the federal government; and to determine priorities."

Society Members Honored by A.W.W.A.

THREE members of the Society, and one Affiliate, were among the five men to receive certificates of honorary membership in the American Water Works Association at its annual convention in Atlantic City, June 1939. They are Frank A. Barbour, Carleton E. Davis, Charles Gilman Hyde, and Harry E. Jordon. Messrs. Barbour, Davis, and Jordan are all past-presidents of the Association. The fifth new honorary member is Beekman C. Little, also a past-president, and secretary emeritus.

Sharing the John M. Goodell prize for 1939 with David G. Thompson was Albert G. Fiedler, Assoc. M. Am. Soc. C.E. The paper on which the award was based, "Some Problems Relating to Legal Control of Use of Underground Water," was published in the *A.W.W.A. Journal* for July 1938.

Among the 19 recipients of the George Warren Fuller awards were six other members of the Society—Messrs. Gerald Eugene Arnold, James Wadsworth Armstrong, John Robert Baylis, William George Banks, Wendell Richard LaDue, and Dana Ewert Kepner. These awards are given each year, one by each section, to members of the A.W.W.A. "for their distinguished service in the water supply field and in commemoration of the sound engineering skill, the brilliant diplomatic talent, and the constructive leadership of men in the Association which characterized the life of George Warren Fuller."

"Engineering and Social Progress"

"ENGINEERING and Social Progress" was the topic chosen by Karl T. Compton for his presidential address before the recent annual convention of the Society for the Promotion of Engineering Education. The meeting was held at the Pennsylvania State College, June 19 to 23.

"If engineering is to be a true profession," said Dr. Compton, "it cannot be restricted to a plane surface of technical proficiency, but must embrace the third dimension of social responsibility and awareness. A profession must have this social roundness, solidity, and depth if it is to be more than an intellectual trade lacking in survival value."

Dr. Compton remarked that "the usual inventory of the engineer's contribution to social progress consists of an enumeration of his additions to mankind's material well being." However, these material things "are but symbols of what seems to me to be a more fundamental achievement—an advance in man's way of thinking, in his outlook on life. I speak of the scientific method and of the engineering mind."

Dr. Compton, briefly tracing the historical development of "this way of thinking," referred to engineering philosophy, "with its fusion of the scientific method with practical application," as one of the greatest syntheses of the human mind. "The historical perspective," he said, "along with the evidence we have of the present power of science and engineering to benefit mankind emphasizes the challenge before us to preserve the engineering method as an essential element of civilization. It also emphasizes the importance of our carrying the synthesis still further so that engineering will be broad enough to cope with new social demands and humble enough to realize that it cannot survive without readapting itself to new conditions."

Efforts for the elevation of professional standards must be continued without abatement, said Dr. Compton, for "the professional attitude is the precursor of social responsibility, the surest prevention against the creation of social hazards by engineers themselves."

"We have here a more difficult problem than the other professions. We are broken up, logically to be sure, into many discrete groups, each highly specialized... We lack the unity of law and medicine.... The practicing engineer is not usually an independent consultant in the sense that most lawyers or doctors are. There are many consulting engineers, of course, but the great majority of our profession is allied with industry or engaged in business.

"These conditions, it seems to me, greatly increase the need for a sound professional spirit among engineers. The opportunities to be unprofessional are greater; therefore the emphasis on a true professional attitude is the more sorely needed. Certainly we have no reason to conclude that these difficulties preclude the professional spirit. 'The essence of the professional status,' as Gano Dunn has said, 'lies in the moral obligation involved in the act of professing. This act is always personal; and it is in the engineer's personal relations to his fellows and to society, and the obligations therein involved. . . that his professional status resides.'

"Unless we can see that the engineer has this moral obligation to his fellows and to society 'we may as well resign ourselves,' as Vannevar Bush recently told the Engineering Council, 'to a gradual absorption as controlled employees. . . .We may as well conclude that we are merely one more group of the population, trained with a special skill. . . with no higher ideals than to serve as directed, and with no greater satisfaction than the securing of an adequate income.'

"I submit that the future of engineering is largely bound up with this struggle for a true professional spirit, and I submit, further, that engineering's continued contribution to social progress is likewise at stake. If society is to respect the engineer and to permit him to function effectively, it must recognize him as a professional man, animated by the precepts of the engineering philosophy, competent and authoritative in his art, and zealous in behalf of the ultimate welfare of the nation.

"If we can insure these qualities, we need have no qualms about the future of engineering or its contributions to social progress, we need have no sense of inferiority as a profession, but instead an abiding faith in the dignity and importance of our work."

The complete text of Dr. Compton's address is to be published in a forthcoming issue of the *Journal of Engineering Education*.

Honorary Degrees Awarded

EACH year during the commencement season honorary degrees are awarded to certain engineers who have made important contributions to the profession. Word of several members of the Society thus honored has already reached Society Headquarters, and the list of these follows. Doubtless there are others of whom the Society has not yet heard.

GIBB GILCHRIST, Doctor of Science, Agricultural and Mechanical College of Texas.

CHARLES FRANCIS GOODRICH, Doctor of Engineering, Dartmouth College.

ERNEST E. HOWARD, Doctor of Engineering, University of Nebraska.

CHARLES F. KETTERING, Doctor of Science, Dartmouth College.

OLE SINGSTAD, Doctor of Engineering, Stevens Institute of Technology.

STEPHEN F. VOORHEES, Doctor of Fine Arts, New York University; Doctor of Engineering, Rensselaer Polytechnic Institute.

A.S.A. Organizes Advisory Committee of Executives

AMERICAN Standards Association has recently announced the organization of an Advisory Committee consisting of 13 of the leading executives of the country. They are: Howard Coonley (chairman); Ralph Budd, M. Am. Soc. C.E.; Floyd L. Carlisle; Karl T. Compton; Lammot du Pont; Lincoln Filene; Walter S. Gifford; Leroy A. Lincoln; J. H. McGraw, Jr.; A. W. Robertson; Alfred P. Sloan, Jr.; E. R. Stettinius, Jr.; and Walter C. Teagle.

Writing of this step in the June issue of *Industrial Standardization*, Edmund A. Prentis, M. Am. Soc. C.E., president of A.S.A., says:

"While the trend is that more and more executives are giving attention to standardization, it is only a decided minority of companies, even of the larger ones, that have yet made it an important managerial function. In a way, the history of the American Standards Association symbolizes the increasing interest and influence of the executive in standardization. In most industries the trail was blazed by the engineer. In fact the A.S.A. was organized by five of the great engineering societies. They soon found, however, that it was necessary to bring in trade associations and the Government on the same basis as the technical societies.

"With the cooperation of management, the work of the A.S.A. has broadened rapidly into new fields which present problems to management as well as to engineers—problems of safety, prevention of occupational diseases, building codes, traffic regulations, and now, standards for consumer goods. These last bring new managerial and merchandising problems.

"The Advisory Committee is the final step in this progressive movement, bringing as it does first-line executives into the national standardization program as the final source of advice on major problems."

Page of Special Interest

THE reproduction of the Veterans Memorial Bridge on page 5 of this issue demonstrates the civil engineer's part in helping to perpetuate a beautiful structure through the use of sound engineering principles, sturdy material, and good construction. This photograph is reproduced through the courtesy of Frank P. McKibben, construction engineer of the job. Gehron and Ross were the architects.

Ridgway Library to Brooklyn Polytechnic

THE PERSONAL scientific library of the late Robert Ridgway, Past-President and Honorary Member of the Society, has been presented to the civil engineering department of Brooklyn Polytechnic Institute by Mrs. Ridgway.

The library consists of some 350 volumes, including many valuable reports and studies of transportation, water supply, and sewerage projects for major cities in all parts of the United States, with many of which Dr. Ridgway was associated in the capacity of consulting engineer. In addition there are over 150 stereopticon slides on the design and construction of Boulder Dam, a complete scale model of the dam, and numerous maps, photographs, and reports of the consulting commission for the dam, of which Dr. Ridgway was a member.

Dr. Ridgway was an honorary alumnus of the Brooklyn Polytechnic Institute and served for many years as Contact Member for the Society and the Student Chapter at the Institute.

Brief Notes from Here and There

THE recent admission of Robert R. McMath to the Society as a Member makes the third generation of Society members from this family. Mr. McMath, who is chairman of the Board of Directors of the Motors Metal Manufacturing Company, Detroit, is the son of the late Francis C. McMath (M. '24) and the grandson of the late Robert Emmet McMath (M. '80). Mr. Robert Emmet McMath, who died in 1918, was the originator of the well-known McMath formula for runoff.

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"STATISTICAL YEAR-BOOK No. 3" of the World Power Conference is obtainable from the American Society of Mechanical Engineers, 29 West 39th St., New York, N.Y., at $5.60 postpaid. The volume contains statistics on the resources, production, stocks, imports, exports, and consumption of power and power sources in most of the countries of the world.

* * * *

NOTE FOR engineering philatelists: The famous "Marly Machine" on the Seine near Paris is featured on a 2 fr. 25 French stamp issued on May 22 to commemorate the Water Exposition at Liége, Belgium. The picture on the stamp is the "modern" plant, which dates from 1859. Its predecessor, built by Rennequin Sualem in 1682 to supply water to Louis XIV's gardens at Versailles, 533 ft above the river, was long admired as "the world's most stupendous mechanical marvel."

* * * *

PRESIDENT of the American Institute of Electrical Engineers for the year beginning August 1 is F. Malcolm Farmer of New York, N.Y. Newly elected vice-presidents are C. T. Sinclair of Pittsburgh, E. E. George of Chattanooga, Albert L. Turner of Omaha, H. W. Hitchcock of Los Angeles, and J. M. Thomson of Toronto. New directors comprise Mark Eldredge of Memphis, R. E. Hellmund of East Pittsburgh, and Frank J. Meyer of Oklahoma City.

NEWS OF ENGINEERS

Personal Items About Society Members

F. J. SANGER of Shanghai has been elected member of council of the Engineering Society of China for the coming session. Two other members of council are also members of the American Society of Civil Engineers—HANS BERENTS and JOHN ANDREWS ELY.

EDWARD S. SHEIRY, for six years professor of structural engineering and head of the civil engineering department at Robert College, has been named head of the civil engineering department at Cooper Union. Professor Sheiry, whose appointment will be effective September 1, succeeds Prof. FRED E. FOSS, who retired in 1938 after twenty-nine years of service.

DAVID H. WHEELER is now employed as field engineer by the Western Precipitation Corporation, with headquarters at 1016 West Ninth Street, Los Angeles, Calif.

BERNARD C. MOORE has accepted a position as structural draftsman with the U. S. Engineer Department on the Red River Dam project. He is located at Denison, Tex. Mr. Moore was formerly with the International Boundary Commission at El Paso, Tex.

PHILIP J. HALE, until recently civil engineer for Arthur G. McKee and Company, of Cleveland, Ohio, is now associate structural engineer in the Procurement Division of the Treasury Department, Washington, D.C.

HOWARD S. REED has announced his return to the general practice of engineering in Phoenix, Ariz., in association with Sheldon K. Baker. This practice was suspended while Mr. Reed was Arizona State Highway Engineer.

WILLIAM L. KUEHNLE, senior engineer of the Little Rock district of the U. S. Engineer Office, has been named principal civilian engineer for the new Tulsa district office, which was established July 1.

JACOB W. T. WANKMULLER, formerly with the Jamaica (N.Y.) Water Supply Company, has accepted a position as assistant sanitary engineer, Grade 4, in the Sanitary Bureau of the New York City Department of Health.

CHARLES W. MATHENY, JR., is now junior assistant engineer for the Florida East Coast Railway, with headquarters at St. Augustine, Fla. Until recently he was county sanitary engineer for the Laurens County (Georgia) Health Department.

FRANK W. EDWARDS has resigned as chief of the Hydraulic Section of the U. S. Engineer Office, 2d New Orleans District, to accept the position of hydraulic engineer for the Panama Canal, Ancon, C.Z.

ALBERT J. R. HOUSTON was recently made president of the Midland Construc-

tors, Inc., Chicago, Ill. He is also an engineer for the Harza Engineering Company.

RAYMOND N. CRUDEN, previously junior engineer in the U. S. Engineer Office at Sacramento, Calif., is now an inspector for the Washington State Highway Department, with headquarters at Olympia, Wash.

PAUL THURBER is at present sanitary engineer for the Okfuskee County (Oklahoma) Health Department, with headquarters at Okemah, Okla. Until recently he held a similar position with the Panhandle District of the Oklahoma State Department of Public Health.

ROY W. CARLSON, associate professor of civil engineering at Massachusetts Institute of Technology, has been awarded the Dudley Medal of the American Society for Testing Materials for his paper on "Drying Shrinkage of Concrete as Affected by Many Factors," which was presented at the 1938 annual meeting of the society. This medal, which commemorates the name of the first president of the society, is awarded to the author of the paper of outstanding merit constituting an original contribution on research.

RICHARD J. LOCKWOOD, formerly president of the Southern Coal, Coke and Mining Company, of St. Louis, Mo., is now president of the Title Insurance Corporation of St. Louis.

HARRY P. HART, associate structural engineer in the San Francisco office of the U. S. Bureau of Public Roads, is being loaned by the government to the government of Ecuador for a year as an adviser on road and bridge works.

CHARLES E. ANDREW is now located in Seattle, Wash., in charge of the two large bridge projects being built at Seattle and Tacoma by the Washington Toll Bridge Authority. Until lately Mr. Andrew was bridge engineer for the San Francisco-Oakland Bay Bridge.

EUGENE J. DAILY, formerly senior engineering aide in the U. S. Engineer Office at Little Rock, Ark., has been promoted to the position of junior engineer in the Corps of Engineers, U. S. Army, at Little Rock.

ARTHUR TYNDALL, who is director of housing construction and under-secretary of mines for the New Zealand government, has been created a Companion of the Most Distinguished Order of St. Michael and St. George in the list of birthday honors conferred by King George VI.

DECEASED

CHARLES WEEDON COCHRAN (M. '21) of Philadelphia, Pa., died in that city on May 26, 1939, at the age of 62. Mr. Cochran had been examiner in charge of the Philadelphia District of the Bureau of Valuation of the Interstate Commerce Commission since 1931. Prior to that he was a civil engineer in the Washington, D.C., Bureau of Valuation of the Commission and, still earlier, had been engaged in levee building and railroad protection work at Cairo, Ill. During the war he served as a major in the Corps of Engineers.

CHARLES PAGE COMEGYS (Assoc. M. '30) contractor and builder of Easton, Md., died on June 5, 1939, at the age of 41. Mr. Comegys was an inspector for the Maryland State Roads Commission from 1917 to 1924, except for one year of war service in the A.E.F. From 1924 to 1928 he was construction superintendent and estimator for H. G. Campion, of Philadelphia, and from 1928 to 1932 a partner in the general contracting firm, Farmer and Comegys. In the latter year he established his own practice.

JOHN RISON FORDYCE (M. '27) consulting engineer of Little Rock, Ark., died at Hot Springs, Ark., on June 9, 1939, at the age of 69. From 1909 to 1912 Mr. Fordyce was president of the Thomas-Fordyce Manufacturing Company. He then established his consulting practice in Little Rock, later supervising the construction of several Mississippi River terminals. During the war he served as a major in the Corps of Engineers, U. S. Army, and in this capacity supervised the construction of Camp Pike (now Camp Robinson) at Little Rock.

ROY C. GOWDY (M. '16) former Director and Vice-President of the Society, died suddenly in Denver, Colo., on June 9, 1939, at the age of 60. In 1906, after

ROY C. GOWDY

subprofessional experience in Colorado, Mr. Gowdy went to the Fort Worth and Denver City Railway Company, subsequently becoming resident engineer. In 1908 he was appointed chief engineer of the company and of the Wichita Valley Lines, continuing in that position (except for a short period) until 1918, when he was appointed corporate chief engineer of the Colorado and Southern Lines. In 1920 he became chief engineer of the Colorado and Southern Railway Company, the Forth Worth and Denver City Railway Company, and the Wichita Valley Lines, which position he held until his death. When District 16 was created in 1930, the Board of Direction appointed Mr. Gowdy its first Director, his term expiring in January 1932. In 1937 and 1938 he was Vice-President. Mr. Gowdy was also active in Local Section affairs, having served as president of both the Texas and Colorado Sections.

The Society welcomes additional biographical material to supplement these brief notes and to be available for use in the official memoirs for "Transactions."

VANN RICHARD PHILLIPS (Assoc. M. '24) with Ford, Bacon and Davis, Inc., of New York, N.Y., died on April 10, 1939, at the age of 55. Mr. Phillips spent his career in railroad work, specializing in valuation. From 1914 to 1921 he was with the New York Central Railroad in varying capacities, and from 1921 to 1924 he was engineer in charge of all work in connection with the appraisal of the Electric Interurban Railway Lines in the state of Michigan. In the latter year Mr. Phillips became engineer on valuation and report work with Ford, Bacon and Davis, Inc.

GUY PINNER (M. '21) since 1931 chief engineer of the American Cyanimid Company, New York, N.Y., died in Bronxville, N.Y., on June 25, 1939, at the age of 51. In 1918, after a variety of early experience, Mr. Pinner became associated with the contracting firm of James Stewart and Company, as engineer in charge of the naval operating base at Norfolk, Va. He then spent several years in South America on engineering projects in connection with large oil developments. From 1925 to 1929 he was vice-president of the Foundation company, and in the latter year he became connected with the American Cyanimid Company.

JULIAN CLEVELAND SMITH (M. '22) president of the Shawinigan Water and Power Company, of Montreal, Canada, died on June 24, 1939, at the age of 61. An American by birth, Mr. Smith spent practically his entire professional career in Canada. In 1903 he was appointed superintendent of the Shawinigan Water and Power Company. He became general superintendent and chief engineer in 1909 and president and managing director in 1933. Mr. Smith was a former president of the Engineering Institute of Canada.

WARREN AYRES TYRRELL (M. '24) for some years designing engineer, Board of Water Supply, New York, N.Y., died June 29, 1939, at the age of 64. From 1903 to 1914 Mr. Tyrrell was engaged in designing and structural engineering work in St. Louis, Mo.—first as a member of the W. A. Tyrrell Engineering Company and, then, of the Markmann-Tyrrell Engineering Company—and from 1914 to 1917 he was an engineer for the Commercial Acid Company, of East St. Louis, Ill. Later Mr. Tyrrell was with the J. G. White Engineering Company for several years before becoming connected with the New York City Board of Water Supply.

Changes in Membership Grades

Additions, Transfers, Reinstatements, and Resignations

From June 10 to July 9, 1939, Inclusive

Additions to Membership

Ackermann, William Carl (Jun. '39), Junior Hydr. Engr., TVA, 701 Union Bldg., Knoxville, Tenn.

Baxter, Allan Hayden (M. '39), (A. E. Baxter Eng. Co.), 344 Delaware Ave., Buffalo, N.Y.

Brown, William Carlton (Assoc. M. '39), Res. Engr., Insp., PWA, 585 Bush St., San Francisco (Res., 3225 Bayo Vista Ave., Alameda), Calif.

Bubb, Grant Edward (Assoc. M. '39), Constr. Supt., E. I. DuPont de Nemours & Co., Wilmington, Del. (Res., 33 South Davis St., Woodbury, N.J.).

Chandler, Benson (Jun. '39), Box 412, Coulee Dam, Wash.

Chapman, Edward John Knowles (Assoc. M. '39), Designing Engr., Sir Wm. Arrol & Co., Ltd., 85 Dunn St., Bridgeton, Glasgow, S.E., Scotland.

Chiarolla, Frank Vito (Jun. '39), Junior Civ. Engr., Grade A, 854 North Figueroa St., Los Angeles, Calif.

Churchill, Milo Albert (Jun. '39), Asst. Hydr. Engr., TVA (Res., 2317 Woodbine Ave.), Knoxville, Tenn.

Cirino, Nicholas (Assoc. M. '39), Regional Engr., Dept. of Agriculture, FSA, 85 Second St., San Francisco (Res., 855 Cedar St., San Carlos), Calif.

Crawford, Edward Miles (M. '39), Chf. Engr., Santa Marta R. R. and Magdalena Fruit Co., Care, Cia Bananera de Costa Rica, San Jose, Costa Rica.

Davis, Paul Garrett (Jun. '39), (Eng. Constr; Co.), 201 Nineteenth St. (Res., 329 Sixteenth St., Apartment 107), Huntington, W.Va.

Davy, Philip Sheridan (Jun. '39), Cons. Engr. (Frank J. Davy & Son), 502 Main St., La Crosse, Wis.

DePuy, Hiram, Jr. (Assoc. M. '39), With Bureau of Reclamation, Box 129, Coulee Dam, Wash.

Dickerson, Lewis Addison (Jun. '39), Junior Engr., U. S. Engr. Dept. at Large, U. S. Engr. Office, Little Rock (Res., 100 Plainview Circle, Park Hill, North Little Rock), Ark.

Field, Arthur Maxwell (M. '39), Industrial Engr., Chamber of Commerce, Hotel Peabody, Memphis, Tenn.

Flod, Walfred Andrew (Jun. '39), Axeman, U. S. War Dept., 1109 Union St., Kingsbury, Calif.

Goodpasture, Robert Abraham (Jun. '39), Junior Engr., U. S. Bureau of Reclamation, 406 Custom House, Denver, Colo.

Gustafson, Edward William (Assoc. M. '39), Asst. Bridge Engr., State Dept. of Public Works, Div. of Highways, Bridge Dept., Box 1499, Sacramento, Calif.

Hickox, Jay Russell (M. '39), Hydr. Engr., C. B. & Q. R. R. (*Retired*), 547 West Jackson Boulevard, Chicago, Ill.

Hinton, Julian Pitts (Jun. '39), Asst. Eng. Aide, Power Section, TVA, 515 Union Bldg., Knoxville, Tenn.

Johnson, George Dugan (Jun. '39), Junior Hydr. Engr., S. Morgan Smith Co., York, Pa.

Kay, Alton Francis (Assoc. M. '39), Res. Engr., Bridge Dept., State Div. of Highways, Box 1499, Sacramento, Calif.

Knoll, Frank John (Jun. '39), Engr., Gen. Chemical Co., Post Rd., Marcus Hook (Res., 934 Saville Ave., Eddystone), Pa.

Lang, Thomas Arthur (Jun. '39), Care, State Rivers and Water Supply Comm., Treasury Pl., Melbourne C 2, Victoria, Australia.

Ludwig, Harvey Fred (Jun. '39), With U. S. Eng. Dept., Sacramento Div., Stockton (Res., 923 South Cabrillo Ave., San Pedro), Calif.

Merriam, John Lafayette (Jun. '38), 1054 Fourteenth St., San Bernardino, Calif.

Mohr, Lawrence Gustav (Jun. '39), Asst. Engr., U. S. Engr. Office, Ithaca, N.Y.

Montell, Frederick Waters (Assoc. M. '39), Associate Highway Engr., State Div. of Highways, 211 State Bldg., San Francisco (Res., 462 Fortuna Ave., San Leandro), Calif.

Murphy, Joseph Aloysius (Jun. '39), Recorder, U. S. Geological Survey, 226 Post Office Bldg., Jamaica (Res., 1770 East 38th St., Brooklyn), N.Y.

Oberle, Francis Nicholas (Jun. '38), Asst. of Physics, Manhattan Coll., 242d St. and Spuyten Duyvil Parkway, New York (Res., 123-18 Ninety-Fifth Ave., Richmond Hill), N.Y.

Petersen, Warren (Jun. '39), Senior Eng. Aide, Met. Dist. Water Supply Comm., 20 Somerset St. (Res., 1209 Boyleston St.), Boston, Mass.

Phimister, Albert (Assoc. M. '39), Surv., U. S. Engrs., New York Dist., 80 St. Marks Pl., St. George, N.Y.

Powers, Spencer Byrd (Jun. '39), Asst. Engr., U. S. Engr. Dept., Sardis, Miss.

Renoud, Gleason LeRoy (Jun. '39), Junior Engr., U. S. Geological Survey, Box 346, Sacramento, Calif.

Robertson, Winfred Talmage (Assoc. M. '39), Designing Engr., Bridge Div., State Highway Dept., Highway Bldg. (Res., 610 Garcelon St.), Olympia, Wash.

Rudd, Edward Irvine (M. '39), Chf. Engr., Public Utilities Comm. of Connecticut, 577 State Office Bldg., Hartford, Conn.

Seufer, Paul Ernest (Jun. '39), Asst. Public Health Engr., State Dept. of Health, 1412 Smith Tower, Seattle, Wash.

Smith, Robert Earl (Jun. '39), 345 Delaware Ave., Dayton, Ohio.

Young, Charles Henry (M. '39), Dist. Engr., State Health Dept. (Res., 721 Baldwin St.), Meadville, Pa.

Membership Transfers

Appleford, Carl Williams (Assoc. M. '26; M. '39), Asst. Engr., Pacific Gas & Elec. Co., 245 Market St., San Francisco, Calif.

Bass, Clark Neil (Assoc. M. '23; M. '39), Chf. Conservation Engr., TVA, Union Ave., Knoxville, Tenn.

Burnette, George Harley (Assoc. M. '17; M. '39), Asst. Chf. Engr., P. & L. E. R. R., Smithfield St., Pittsburgh, Pa.

Callahan, Felix Wood (Jun. '37; Assoc. M. '39), Supervisor of Operations, WPA, Dist. 19, 912 Western Reserve Bldg. (Res., 2212 Webster), San Angelo, Tex.

Comm, Edward Daniel (Jun. '34; Assoc. M. '39), Dist. Engr., WPA, Box 971, Bismarck, N.Dak.

Crandall, Frederick Bruce (Jun. '36; Assoc. M. '39), Div. Supervisor, Traffic Eng. Div., State Highway Dept. (Res., 1792 North Church), Salem, Ore.

Davison, James Golden (Assoc. M. '36; M. '39), Gen. Supt., Francis A. Canuso & Son (Res., 116 Roselle Ave.), Niagara Falls, N.Y.

Gardner, William McGregor (Assoc. M. '29; M. '39), Supt., Constr. and Maintenance, Montreal Tramways Co., 159 Craig St., West, Montreal, Canada.

Hahn, Arthur Robert (Jun. '34; Assoc. M. '39), Sales Engr., Massey Concrete Products Corporation, 50 Church St., New York, N.Y. (Res., 212 Coeyman Ave., Nutley, N.J.)

James, Robert Trafford (Assoc. M. '29; M. '39), Civ. Engr. (R. T. James & Partners), 6 Lower Grosvenor Pl., London, S. W. 1 (Res., Banacle Field, Brook, Godalming, Surrey), England.

Jones, Vincent Knowles (Assoc. M. '23; M. '39), Vice-Pres., New Mexico Constr. Co., Box 1707 (Res., 727 Gaylord St.), Denver, Colo.

Libutti, Albert (Jun. '30; Assoc. M. '39), Engr. and Estimator, M. A. Gammino Constr. Co., 728 Valley St. (Res., 5 Tower St.), Providence, R.I.

McCarthy, Gerald Timothy (Jun. '35; Assoc. M. '39), Engr., Parsons, Klapp, Brinckerhoff & Douglas, Apartado 168, Caracas, Venezuela

McKee, Hugh Thomas Peter (Jun. '35; Assoc. M. '39), City Engr., City Hall (Res., 205 Congress St.), Cohoes, N.Y.

Norris, Walter Henry (Assoc. M. '05; M. '39), Asst. Engr. of Structures, Maine Cent. R. R., 222 St. John St., Portland, Me.

Parker, George Mason (Jun. '24; Assoc. M. '27; M. '39), Associate Engr., U. S. Engr. Office, 415 Post Office and Court House, Norfolk, Va.

Posey, Chesley Johnston (Jun. '29; Assoc. M. '39), Associate Engr., Iowa Inst. of Hydr. Research; Asst. Prof., Hydraulics and Structural Eng., State Univ. of Iowa, Eng. Bldg., Univ. of Iowa, Iowa City, Iowa.

Post, Clarence Willard (Assoc. M. '16; M. '39), Deputy State Administrator and Chf. Engr., New York State WPA, Old Post Office Bldg., Albany, N.Y.

Price, Thomas Malcolm, Jr. (Jun. '30; Assoc. M. '39), Asst. Cartographic Engr., Chart Div., U. S. Coast and Geodetic Survey, Washington, D.C.

Rinne, John Elmer (Jun. '31; Assoc. M. '39), Engr., Standard Oil Co. of California, 225 Bush St., San Francisco (Res., 1024 Merced St., Berkeley), Calif.

Weiner, Bernard Louis (Jun. '23; Assoc. M. '31; M. '39), With Madigan-Hyland, 28-04 Forty-First Ave., Long Island City (Res., 985 Adee Ave., New York), N.Y.

Wilson, Samuel Allan (Jun. '28; Assoc. M. '39), Designing and Estimating Engr., Bethlehem Steel Co., Fabricated Steel Constr. (Res., 420 Hickory St.), Bethlehem, Pa.

Reinstatements

Fraleigh, Philip Waldorf, Assoc. M., reinstated June 12, 1939.

MacCallum, Clarence, M., reinstated June 21, 1939.

Williams, John Alonzo, M., reinstated June 22, 1939.

Wright, Marshall Sheldon, Assoc. M., reinstated June 19, 1939.

Resignations

Bowen, Charles Kennard, M., resigned, July 6, 1939.

Chamberlin, Wilbur Henry, Jun., resigned June 30, 1939.

Hepworth, Clare, Jun., resigned July 1, 1939.

Lewis, Walter Smith, Jun., resigned June 21, 1939.

TOTAL MEMBERSHIP AS OF JULY 9, 1939

Members	5,666
Associate Members	6,412
Corporate Members	12,078
Honorary Members	27
Juniors	3,955
Affiliates	74
Fellows	1
Total	16,135

Applications for Admission or Transfer

Condensed Records to Facilitate Comment from Members to Board of Direction

August 1, 1939 — NUMBER 8

The Constitution provides that the Board of Direction shall elect or reject all applicants for admission or for transfer. In order to determine justly the eligibility of each candidate, the Board must depend largely upon the membership for information. Every member is urged, therefore, to scan carefully the list of candidates published each month in CIVIL ENGINEERING *and to furnish the Board with data which may aid in determining the eligibility of any applicant. It is especially urged that a definite recommendation as to the proper grading be given in each case, inasmuch as the grading must be based upon the opinions of those who know the applicant personally as well as upon the nature and extent of his professional experience. Any facts derogatory to the personal character or professional reputation of an applicant should be promptly communicated to the Board.*

Communications relating to applicants are considered strictly confidential.

The Board of Direction will not consider the applications herein contained from residents of North America until the expiration of 30 days, and from non-residents of North America until the expiration of 90 days from the date of this list.

MINIMUM REQUIREMENTS FOR ADMISSION

Grade	General Requirement	Age	Length of Active Practice	Responsible Charge of Work
Member	Qualified to design as well as to direct important work	35 years	12 years	5 years RCM*
Associate Member	Qualified to direct work	27 years	8 years	1 year RCA*
Junior	Qualified for sub-professional work	20 years	4 years	
Affiliate	Qualified by scientific acquirements or practical experience to cooperate with engineers	35 years	12 years	5 years RCM*

* In the following list RCA (responsible charge—Associate Member standard) denotes years of responsible charge of work as principal or subordinate, and RCM (responsible charge—Member standard) denotes years of responsible charge of IMPORTANT work, i. e., work of considerable magnitude or considerable complexity.

FOR MEMBER

ANDERSON, JOHN (Assoc. M.), Charleston, S.C. (Age 51) (Claims RC 24.2 D 4.8) Sept. 1919 to date with The Citadel (Military Coll. of South Carolina) as Asst. Prof., Associate Prof., and (since June 1929) Prof. of Civ. Eng.

ANDREWS, WILLIAM EARLE, New York City. (Age 41) (Claims RCA 3.8 RCM 12.1) 1938 to date in private practice as Cons. Engr., previously Gen. Mgr.-Cons. Engr., New York World's Fair; Chf. Engr.-Gen. Supt., New York City Park Dept.

BERRY, CARL MORRISON (Assoc. M.), Portland, Ore. (Age 35) (Claims RCA 6.2 RCM 5.8) Aug. to Oct. 1938 Div. Asst. Engr., and Oct. 1938 to date Property Div. Engr., U. S. Bonneville Project; previously Engr., Quantities Dept., Consolidated Bldrs., Inc., Mason City, Wash.; Geodetic and Cadastral Engr., Chf. of Triangulation, U. S. Bureau of Reclamation, Coulee Dam, Wash.

BERRY, ROY NEIL, Seattle, Wash. (Age 38) (Claims RCA 1.6 RCM 11.0) Nov. 1935 to May 1936 and Nov. 1937 to date Associate Engr., Dept. of Public Works, Puget Sound Navy Yard; in the interim Design Engr., Sound View Pulp Co., Everett, Wash., Design Engr., The Austin Co., Seattle, and in private practice as Cons. Engr., Miami, Fla.; previously Asst. Engr., Washington State Dept. of Public Works.

DARDEL, WALTER, Berne, Switzerland. (Age 41) (Claims RCA 3.8 RCM 5.9) Dec. 1933 to date Cons. Engr. in Gen. Eng.; previously Associate Engr. with Cons. Archt.

ELLER, EDWIN CAMERON (Assoc. M.), New York City. (Age 40) (Claims RCA 2.5 RCM 8.5) Jan. 1934 to Jan. 1939 Legal Representative and Chf. Res. Engr. with Chester M. Everett, Cons. Engr.; April 1939 to date with Garcia & Cantillo, Engrs. & Contrs., Bogota, Colombia.

GUTIERREZ-SALINAS, JORGE BRAULIO, Buenos Aires, Argentina. (Age 35) (Claims RCA 3.4 RCM 8.1) May 1931 to Sept. 1935 and March 1937 to date Chf. Designing Engr., Dept. of Public Works, Argentine Govt.; in the interim Inspector Engr., Argentine Govt.

HASWELL, JOHN ROBERT (Assoc. M.), State College, Pa. (Age 53) (Claims RCA 13.8 RCM 13.4) April 1920 to July 1930 Asst. Prof., July 1930 to July 1934 Associate Prof. and July 1934 to date Prof., The Pennsylvania State College.

KOUBA, ALBERT PETER, Paoli, Pa. (Age 45) (Claims RCA 6.7 RCM 12.6) April 1912 to date with Pennsylvania R.R. as Tracer, Draftsman, Inspector, etc., and (since Oct. 1931) Draftsman, Office of Engr. of Bridges and Bldgs.

LOVAN, CHARLES FELIX (Assoc. M.), Jacksonville, Fla. (Age 38) (Claims RCA 1.1 RCM 13.5) Feb. 1937 to date member of firm, Hillyer and Lovan, Engrs. and Contrs.; previously Field Engr. and Foreman with The Solvay Process Co., Ammonia Plant, Nitrogen Div., Hopewell, Va.

MCCONNELL, JAMES ALEXANDER, Winchester, Mass. (Age 41) (Claims RCA 14.3 RCM 2.8) July 1934 to Jan. 1938 and Aug. 1938 to date with PWA as Res. Engr. Inspector and Chf. Res. Engr. Inspector; in the interim Supt., V. Barletta Co., Roslindale, Mass.

MOORE, RUSSELL BERNARD (Assoc. M.), Indianapolis, Ind. (Age 43) (Claims RCA 4.1 RCM 12.0) July 1927 to date in private practice as Russell B. Moore Co., Cons. Engrs.

NOCE, DANIEL, Memphis, Tenn. (Age 44) (Claims RCA 3.3 RCM 15.1) April 1917 to date with U. S. Army as 2nd Lieut., 1st Lieut., Capt. and at present Major, being student instructor in military engineering, Asst. Dist. Engr., etc., and (since July 1937) Dist. Engr.

RILEY, JOHN PHILIP (Assoc. M.), Jackson Heights, N.Y. (Age 38) (Claims RCM 7.1) Jan. 1938 to date Borough Supt., Div. of Bldgs., Dept. of Housing and Bldgs., New York City; previously Civ. Engr., Parsons, Klapp, Brinkerhoff and Douglas, New York City; Asst. Regional Director, Region I, U. S. RA, Washington, D.C.; Asst. Deputy Administrator, Constr. Div., NRA, Washington, D.C.

SHELDON, GEORGE BELLEVUE, JR., Arlington, Va. (Age 41) (Claims RCA 3.2 RCM 6.3) Dec. 1931 to date Asst. Engr., Engr., and Senior Engr., Public Bldgs. Branch, Procurement Div., Treasury Dept.

SHERRARD, HOWARD MACOUN (Assoc. M.), Sydney, N.S.W., Australia. (Age 42) (Claims RC 17.0 D 4.6) April 1926 to date with Dept. of Main Roads, New South Wales as Designing Engr., Bridge and Designing Engr., and (since Aug. 1928) Asst. Chf. Engr., being Prin. Asst. to Chf. Engr.

VAUGHAN, HARRY BRIGGS, JR., Washington, D.C. (Age 51) (Claims RCA 2.7 RCM 20.0) May 1917 to date with U. S. Army as Capt., at various times acting as Company Commander, Asst. to Dist. Engr., Asst. to Div. Engr., etc., and (since July 1937) Asst. to Res. Member, Board of Engrs. for Rivers and Harbors, and Chf., Marine Design Sec., Office of Chf. of Engrs., War Dept.

WORTHAM, HARRY ADAMS, Atlanta, Ga. (Age 53) (Claims RCA 3.3 RCM 26.1) Oct. 1934 to date with FEA of PW as State Engr. Inspector, Project Engr., Associate Regional Engr., and (since March 1939) Acting Regional Director, Region No. 3 (9 states); previously organized and was Pres. of Wortham Constr. Co., Louisville, Ky.

FOR ASSOCIATE MEMBER

COOKMAN, WILLARD GEORGE MINTER (Junior), Joliet, Ill. (Age 32) (Claims RCA 3.5 RCM 1.0) Oct. 1936 to date Inspector (Dredge), U. S. Engr. Dept., acting as Surveyman, Asst. Engr. (Civ.) and Asst. Engr. (Highway); previously Engr., Gast Constr. Co., Warsaw, Ind.; Field Recorder, U. S. Coast & Geodetic Survey, CWA Project.

COONS, ALFRED DEVORE (Junior), Davis, Calif. (Age 32) (Claims RCA 4.0 RCM 0.0) Jan. 1931 to date Res. Engr., Coll. of Agriculture, Univ. of California.

CUSHING, PAUL JOSEPH (Junior), Oakland, Calif. (Age 29) (Claims RCM 5.3) July 1931 to date with Hydraulic Dredging Co., Ltd., as Asst. Div. Engr., and since March 1934 Div. Engr.; 1936 to 1939 Vice-Pres. and Treas., and since April 1939 Pres.

DAVIS, ROBERT OLIN (Junior), Chattanooga, Tenn. (Age 32) (Claims RCA 1.6 RCM 0.0) June 1930 to Nov. 1935 Jun. Engr. and Dec. 1935 to date Asst. Engr., U. S. Geological Survey, Topographic Branch, Washington, D.C.

DAVIS, ROY EDWARD, Washington, D.C. (Age 34) (Claims RCA 2.1 RCM 0.0) Dec. 1935 to date with TVA, Knoxville, Tenn., assisting in design and testing of hydraulic structures and later in charge of construction of models for testing section; previously Engr., Brown County Commrs.; Rodman with Prof. C. E. Calderwood, Kansas State Coll.

DONALDSON, WILLIAM ELMER, Lakewood, Ohio (Age 33) (Claims RCA 2.2 RCM 0.0) July 1938 to date Designer, American Steel & Wire Co., Cleveland; previously Checker, Republic Steel Corporation, Corrigan-McKinney Plant, Cleveland; Estimator and Designer, Carnegie-Illinois Steel Corporation, Youngstown, Ohio Works; Draftsman and Field Engr., Arthur G. McKee & Co., Engrs. & Contrs., Cleveland.

DUCHARME, JEAN MARC (Junior), Cambridge, Mass. (Age 28) (Claims RCA 2.9 RCM 0.0) May 1939 to date Designer, Crandall Dry Dock Engrs., on design of sheet-pile bulkheads; previously Designer, Jackson & Moreland, Cons. Engrs., Asst. Engr., J. R. Worcester & Co., Cons. Engrs., Res. Engr., Standard Fruit & Steamship Co., and Res. Engr., United Fruit Co.

FOX, RICHARD BURKHOLDER, Mt. Pleasant, Pa. (Age 36) (Claims RC 2.2 D 1.0) Sept. 1938 to date student (Pennsylvania State College); July 1932 to Sept. 1938 in private practice as Contr. and Designer.

FURNESS, LAWTON WILLIAMS (Junior), Hartford, Conn. (Age 32) (Claims RCA 3.8 RCM 0.0) May 1929 to date with Water Resources Branch, U. S. Geological Survey as Jun. Hydr. Engr., and (since March 1935) Asst. Hydr. Engr., acting as Office Engr. and 1st Asst. to Dist. Engr.

GAMET, MERRILL BARTLETT, Evanston, Ill. (Age 34) (Claims RCA 1.0 RCM 0.0) Sept. 1928 to Sept. 1938 Instructor in, and Sept. 1938 to date Asst. Prof. of, Civ. Eng., School of Eng., Northwestern Univ.

GEORGE, PRESTON WILLIAM (Junior), Oklahoma City, Okla. (Age 32) (Claims RCA 2.4 RCM

0.0) Feb. 1931 to date with Oklahoma State Highway Dept. as Inspector, Instrumentman, and (since April 1939) Draftsman.

GUTHRIE, MARION CULBERTSON (Junior), Bartlesville, Okla. (Age 32) (Claims RCA 1.9 RCM 0.0) Jan. 1937 to date Engr. and Engr.-Draftsman, Phillips Petroleum Co.; previously with Kansas State Highway, Topeka, Kans., as Draftsman, Instrumentman, Concrete Inspector, and Recorder.

HUTTO, WALTER CLYDE, Knoxville, Tenn. (Age 32) (Claims RCA 5.3 RCM 0.0) Jan. 1937 to date Asst. Structural Engr., Design Sec., Constr. Plant Div., Constr. Dept., TVA; previously Designer and Draftsman, Bridge Div., South Carolina Highway Dept., Columbia, S.C.; Chf. Draftsman and Computer, Local Control Surveys, Columbia, S.C.

ITANI, SALAHUDDIN (Junior), Beirut, Syria. (Age 30) (Claims RCA 4.4 RCM 3.0) April 1937 to date Irrigation Engr., Govt. of Iraq, Dept. of Irrigation; previously member of firm S. & F. Itani, Archts. and Engrs.

JOBES, JAMES GIBSON (Junior), Los Angeles, Calif. (Age 32) (Claims RCA 2.2 RCM 7.8) June to Dec. 1929 and May 1934 to date with U. S. Engr. Office as Inspector (Eng.), Associate Engr., and (since Aug. 1935) Associate Engr. and Engr.

KAUFMAN, VIVIAN GREGOR, Vicksburg, Miss. (Age 40) (Claims RCA 1.5 RCM 2.0) June 1934 to date with U. S. Waterways Experiment Station successively as Gage Reader, Eng. Aide, Sub-Inspector, Jun. Engr., and (since July 1937) Jun. Engr. and Asst. Engr., being Engr. in responsible charge of section of hydraulic laboratory.

KELLY, EDMONDE BERNARD (Junior), St. Paul, Minn. (Age 29) (Claims RCA 2.7 RCM 0.0) Feb. 1937 to date Engr. Officer, Corps of Engrs., U. S. Army; previously Draftsman, Gibbs and Hill, Inc.; Inventory Asst. (Eng.), Constr. Div., Consolidated Gas Co.; Inspector of Track, Track Div., Board of Transportation, New York City.

KING, OSCAR LLOYD, Kingsport, Tenn. (Age 33) (Claims RC 11.2 D 8.4) June 1931 to Jan. 1932 Res. Engr., and Oct. 1934 to date City Engr. in charge of Dept. of Public Works and Water-Works, City Eng. Dept.; in the interim Engr. in private practice; graduate student, Univ. of Tenn.; Senior Engr., Tennessee Forestry Dept.

LEWIS, CHARLES EDWARD (Junior), Pierre, S.Dak. (Age 32) (Claims RCA 2.8 RCM 4.0) 1932 to date with South Dakota State Highway Comm. as Checker, Inspector, Res. Engr., Draftsman, Designer, Res. Engr., and (since 1935) Asst. Bridge Engr.

LOANE, EDWARD SICKEL (Junior), Baltimore, Md. (Age 31) (Claims RCA 2.5 RCM 1.5) March 1930 to date Asst. in Office of Vice-Pres., Pennsylvania Water & Power Co.

LYNN, CHARLES FERGUSON, Columbia, S.C. (Age 34) (Claims RCA 5.7 RCM 0.0) Nov. 1933 to date County Engr., Richland County, S.C.

MABBOTT, LYLE WILLARD (Junior), East Lansing, Mich. (Age 32) (Claims RCA 1.3 RCM 0.0) Sept. 1937 to date Research Asst. and Instructor in Civ. Eng., Michigan State Coll.; previously with Nebraska Dept. of Roads and Irrigation as Office Asst. to Constr. Engr., and Jun. Project Engr.; Inspector and Instrumentman, Nebraska State Highway Dept.

MORTON, WILLIAM (Junior), Portland, Ore. (Age 32) (Claims RCA 1.2 RCM 0.0) Jan. 1939 to date Laboratory Engr., Washington State Toll Bridge Authority; previously Constr. Foreman, U. S. Coast Guard; Jun. Engr., Washington State Dept. of Conservation & Development; superintending pumping installation at Univ. of Washington Hydraulic Laboratory.

MUNSON, GEORGE POINDEXTER, JR. (Junior), Mt. Vernon, Tex. (Age 31) (Claims RCA 3.6 RCM 0.0) Jan. 1932 to date with Texas State Highway Dept. as Rodman, Instrumentman, Mixer Inspector, Asst. Res. Engr. and Chf. of Party, Draftsman, Computer, Inspector, Asst. Res. Engr., and (since July 1938) Jun. Res. Engr.

SAMSON, SAMUEL, Carlsbad, N.Mex. (Age 39) (Claims RCA 10.2 RCM 0.0) Sept. 1937 to date City Engr.; previously Cons. Engr., building, surveying, and irrigation; with New Mexico State Highway Dept., Santa Fe, N.Mex., as Levelman, Inspector, Structural Draftsman, Instrumentman, Designer, and Project Engr. on Federal Aid highway construction and bridges.

WILSON, BRYAN, Girard, Kans. (Age 42) (Claims RC 6.6 D 2.1) July 1931 to June 1935 and June 1937 to date with Kansas State Highway Comm. as Supervisor of Maintenance, Dist. 4, Concrete Inspector, Instrumentman, Asst. Traffic Engr., and (since June 1938) Asst. Safety Engr., Topeka, Kans.; in the interim with Kansas WPA as Area Engr., Asst. Supervisor and Supervisor of Operations.

FOR JUNIOR

ACKENHEIL, ALFRED CURTIS, JR., Pittsburgh, Pa. (Age 21) 1939 B.S. in C.E., Univ. of Pittsburgh.

AHRENS, FREDERICK CONRAD, St. Louis, Mo. (Age 21) 1939 B.S.C.E., Purdue Univ.

ALLAIRE, JAMES MORTIMER, Brooklyn, N.Y. (Age 22) 1939 B.S. in C.E., Cooper Union Inst. Tech.

ALLEN, JOHN WINFIELD, Mill City, Ore. (Age 21) 1939 B.S. in Civ. Eng., Ore. State Coll.

ANDERSON, DONALD ERNEST, Devils Lake, N.Dak. (Age 22) 1939 B.S. in Arch. Eng., Univ. of Ill.

ANDERSON, LESLIE ALFRED, Minneapolis, Minn. (Age 21) 1939 B.C.E., Univ. of Minn.

ARMENTROUT, MICHAEL KING, Pittsburgh, Pa. (Age 23) 1939 B.S.C.E., W.Va. Univ.

ARNOLD, ROBERT JAY, New York City. (Age 24) 1939 B.S., Columbia Univ. Eng. School; at present with Spencer, White & Prentis, on surveying party.

ASHBAUGH, LEWIS EUGENE, JR., Denver, Colo. (Age 26) 1939 B.S. in Civ. Eng., Univ. of Colo.

ASHMORE, GEORGE BYRON, Chipley, Fla. (Age 22) 1939 B.S. in Civ. Eng., Univ. of Fla.; at present with Florida State Road Dept.

AXELSON, EDWARD WILLIAM, Minneapolis, Minn. (Age 22) 1939 B.C.E., Univ. of Minn.

AYGARN, HEBER HARRELL, Back Bay, Va. (Age 21) 1939 B.S. in Civ. Eng., Va. Pol. Inst.

BACHAND, EMILE PATRICK, Weippe, Idaho. (Age 28) 1939 B.S. in C.E., Univ. of Idaho.

BAINTER, ROBERT GOODLIVE, Columbus, Ohio. (Age 25) 1939 B.C.E., Ohio State Univ.; at present Draftsman, Ohio Dept. of Highways Testing Laboratory, Soils Sec.

BALDWIN, JOHN RAMSEY, Lewiston, Idaho. (Age 22) 1939 B.S. in C.E., Univ. of Idaho.

BAUER, DAVID EARL, Philadelphia, Pa. (Age 23) 1939 B.S., Pa. State Coll.

BENNETT, CARL MELVIN, Boulder, Colo. (Age 23) 1939 B.S. in Civ. Eng., and B.S. in Arch. Eng., Univ. of Colo.

BENT, PAUL CAP, Buhl, Idaho. (Age 25) 1939 B.S. in C.E., Univ. of Idaho.

BENWAY, WENDELL HAYDEN, East Berkshire, Vt. (Age 21) 1939 B.S. in C.E., Univ. of Vt.

BINGER, WILSON VALENTINE, Greenwich, N.Y. (Age 22) 1938 A.B. Harvard Coll. 1939 S.M. in Eng., Harvard Univ.

BODHAINE, GEORGE LAWRENCE, Puyallup, Wash. (Age 21) 1939 B.S. in C.E., Wash. State Coll.

BONELL, WILLIAM HENRY, Pasadena, Calif. (Age 23) 1939 B.S., S.Dak. State Coll. 1939 M.S., Calif. Inst. Tech.

BOONE, MONTELLE NELSON, Grafton, N.Dak. (Age 24) 1939 B.S. in C.E., Univ. of N.Dak.

BOTTOMS, ROBERT GALE, Little Rock, Ark. (Age 21) 1939 B.S. in Civ. Eng., Mich. State Coll.; at present with U. S. Engrs.

BOWERS, CHESTER HUFFMAN, Fort Wayne, Ind. (Age 22) 1939 B.S.C.E., Purdue Univ.

BOYER, HERBERT CLARENCE, Dwight, Ill. (Age 21) 1939 B.S.C.E., Purdue Univ.

BRENMAN, HARRY, Batavia, N.Y. (Age 21) 1939 B.S.C.E., Purdue Univ.

BROWN, DONALD RAYMOND, Healdsburg, Calif. (Age 24) 1939 B.S., Ore. State Coll.

BROWN, EDWARD RUSSELL, Arlington, Va. (Age 21) 1939 B.S. in Civ. Eng., Va. Pol. Inst.

BURKE, ROBERT WAYLAND, Urbana, Ill. (Age 30) 1939 B.S. in C.E., Univ. of Ill.

CAMPBELL, JOHN ALLISON, Aspinwall, Pa. (Age 22) 1939 B.S. in Civ. Eng., Carnegie Inst. Tech.

CAMPBELL, WILLIAM CRAWFORD, JR., Fanwood, N.J. (Age 25) 1939 B.S. in C.E., Newark Coll. of Eng.

CANON, JEAN HARTFORD, Bloomfield, N.J. (Age 21) 1939 B.S. in C.E., Newark Coll. of Eng.

CERUTTI, EUGENE JOHN, Plainfield, Vt. (Age 23) 1939 B.S. in C.E., Univ. of Vt.

CHAPMAN, IRA THOMAS, Sumner, Ill. (Age 22) 1939 B.S. in Civ. Eng., Univ. of Ill.

CHAPPELL, CARL JAMES, Fort Smith, Ark. (Age 27) (Claims RC 1.5) July 1938 to date Jun. Hydr. Engr., U. S. Geological Survey, Water Resources Branch; previously with U. S. Bureau of Public Roads as Student Highway Engr., Jun. Highway Engr., and Jun. Materials Engr.

CHRISTIANO, NATALE ANTHONY, Pittsburgh, Pa. (Age 23) 1939 B.S. in Civ. Eng., Carnegie Inst. Tech.

CLARK, GERALD DALE, Corvallis, Ore. (Age 24) 1939 B.S., Ore. State Coll.

CLAVAN, BERNARD PAUL, Philadelphia, Pa. (Age 24) 1939 B.S. in San. Eng., Pa. State Coll.

COLLINS, LOREN DALE, Orleans, Ind. (Age 21) 1939 B.S.C.E., Purdue Univ.

COLVIN, WILLARD LEROY, Bloomfield, N.J. (Age 23) 1939 B.S. in C.E., Newark Coll. of Eng.

CONSOLI, JOSEPH JOHN, Clairton, Pa. (Age 22) 1939 B.S.C.E., Purdue Univ.

COONY, JOHN PATRICK, Stockton, Calif. (Age 23) 1938 B.S. in C.E., Univ. of S. Calif.; Jan. 1939 to date Jun. Engr., U. S. Engr. Dept.

CORTRIGHT, DONALD NATHAN, Sandwich, Ill. (Age 25) 1939 B.S. in Civ. Eng., Univ. of Ill.

CROSSON, RAYMOND LOGAN, JR., Hastings, Neb. (Age 23) 1939 B.S. in Civ. Eng., Univ. of Nebr.

DAVIS, PIERCE WINSTON, Loogootee, Ind. (Age 21) 1939 B.S.C.E., Purdue Univ.

DAY, ELROY KENNETH, North Berwick, Maine. (Age 25) 1939 B.S. in C.E., Univ. of Maine.

DETHOFF, DONALD COMPPEN, Reading, Pa. (Age 23) 1939 B.S. in Arch. Eng., Pa. State Coll.

DOMORSKI, BRUCE PAUL, West Orange, N.J. (Age 23) 1939 B.S. in C.E., Newark Coll. of Eng.

DROGIN, LEONARD ROBERT, Queens Village, N.Y. (Age 22) 1939 B.C.E., Coll. of City of N.Y.

EBERT, EDWARD DARWIN, Champaign, Ill. (Age 22) 1939 B.S. in Civ. Eng., Univ. of Ill.

EGGER, MATHIAS, Newark, N.J. (Age 22) 1939 B.S. in C.E., Newark Coll. of Eng.

ELLIOTT, THOMAS COLGATE, Bluefield, W.Va. (Age 25) 1939 B.S. in Civ. Eng., Va. Pol. Inst.

ENGSTROM, HAROLD JAMES, JR., Little Rock, Ark. (Age 20) 1939 B.S.C.E., Univ. of Ark.

EVANS, GEORGE, Denver, Colo. (Age 23) 1939 B.S. in Civ. Eng., Univ. of Colo.

EVANS, ROBERT BAUR, Glen Rock, N.J. (Age 20) 1939 B.S. in San. Eng., Lehigh Univ.

FARNETI, NELLO, Chicago, Ill. (Age 23) 1939 B.S. in Arch. Eng., Univ. of Ill.

FARNSWORTH, GEORGE LESTER, JR., Ottawa, Ill. (Age 21) 1939 B.S. in Civ. Eng., Univ. of Ill.

FARR, FREDERICK, JR., Hamilton, Ohio. (Age 21) 1939 B.S.C.E., Purdue Univ.

FARROW, WILLIAM HENRY, Corvallis, Ore. (Age 22) 1939 B.S. in Civ. Eng., Ore. State Coll.

FATOUT, ROBERT HUGH, Indianapolis, Ind. (Age 22) 1939 B.S.C.E., Purdue Univ.

FEREBAUER, ROBERT WOODALL, Idaho Falls, Idaho (Age 26) 1939 B.S. in C.E., Univ. of Idaho.

FIALA, JOHN JOSEPH, New York City. (Age 21) 1939 B.S. in C.E., Cooper Union Inst. Tech.

FISCHER, WILLIAM, Letha, Idaho. (Age 28) 1939 B.S. in C.E., Univ. of Idaho.

FORNEY, EVERETT HUSTON, Forest, Ohio. (Age 22) 1939 B.S. in C.E., Ohio Northern Univ.

FORTNEY, GLEN ODUS, Keyser, W.Va. (Age 20) 1939 B.S.C.E., W.Va. Univ.

FRANK, WILLIAM FREDERICK, Pueblo, Colo. (Age 21) 1939 B.S. in Civ. Eng., Univ. of Colo.

FRASER, EDWARD SMITH, JR., Chicago, Ill. (Age 21) 1939 B.S. in Civ. Eng., Univ. of Ill.

FRYE, DONALD EDWARD, Knoxville, Tenn. (Age 22) 1939 C.E., Univ. of Cin.; at present with TVA as Asst. Eng. Aide, on power studies and hydraulic computations.

FUDGE, FRANCIS JOHN, Xenia, Ohio. (Age 23) 1939 B.S. in C.E., Ohio Northern Univ.

FULLER, CHARLES GRAY, Indianapolis, Ind. (Age 23) 1939 B.S. in Civ. Eng., Rose Pol. Inst.

GARFUNKLE, MORRIS HIRSCH, JR., Newark, N.J. (Age 21) 1939 B.S. in C.E., Newark Coll. of Eng.

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